Canadian Transport Commission
Railway Transport Committee

Commission canadienne des transports
Comité des transports par chemin de fer

# The Transport of Dangerous Commodities by Rail in the Toronto Census Metropolitan Area: A Preliminary Assessment of Risk

Prepared by
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For the
Canadian Transport Commission
Railway Transport Committee

May 1983

Commission canadienne des transports | Canadian Transport Commission

## LETTER OF TRANSMITTAL

### THE TRANSPORT OF DANGEROUS COMMODITIES BY RAIL IN THE TORONTO CENSUS METROPOLITAN AREA: A PRELIMINARY ASSESSMENT OF RISK

To interested parties:

As a result of a public meeting held in Toronto on June 11, 1982, the Railway Transport Committee arranged for a study of the transport of dangerous commodities by rail in the Toronto Census Metropolitan Area. This study, carried out by Dr. Ian Burton, an independent consultant to the Committee, and Mr. Keith Post of the Committee's staff, has now been completed. Although individual Commissioners have examined the study, the status of the report is that its content and recommendations have not yet been formally considered by the Committee; therefore, the recommendations contained therein do not have the status of Committee orders or decisions.

The Committee has decided that the study should be distributed to the various interested parties. Comments, addressed to the undersigned, should be submitted by August 31, 1983.

The Railway Transport Committee will consider the study in the light of comments received and will inform the various parties of the results of its deliberations.

J. O'Hara

J. O'Hara,
Secretary,
Railway Transport Committee,
Canadian Transport Commission,
Ottawa.
K1A 0N9

May 18, 1983

Canada

**NOTE**

This study is in part the work of staff of the Railway Transport Committee, but it is distributed as a report whose content and recommendations have not yet been formally considered or endorsed by the Committee. Therefore, the recommendations contained therein do not have the status of Committee orders or decisions.

# THE TRANSPORT OF DANGEROUS COMMODITIES BY RAIL IN THE TORONTO CENSUS METROPOLITAN AREA: A PRELIMINARY ASSESSMENT OF RISK

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KEITH POST

## PREFACE

This report has been prepared by the Staff of the Regional Office of the Railway Transport Committee in Toronto under the direction of Mr. Keith Post. Dr. Ian Burton, has served as consultant to the study and prepared the first draft of the text.

We wish to acknowledge the assistance of Mr. Glen Swanson, General Manager, Operation and Maintenance of Canadian Pacific Railway Eastern Region, and Mr. John Clark, Regional Manager - Operations of Canadian National Railway Great Lakes Region, who each helped by making data and statistics readily and speedily available to us, and for arranging inspection tours by hi-rail car on CP and CN tracks throughout the Toronto Area.

We also wish to record the stimulus given to our work by concerned citizens and local political leaders. Their interest in our progress and the speed of our work are acknowledged.

# TABLE OF CONTENTS


| | | Page |
|---|---|---|
| Preface | | i |
| Table of Contents | | ii |
| List of Figures | | iii |
| List of Tables | | iv |
| List of Appendix Tables | | v |
| Executive Summary | | vi |
| Recommendations | | ix |
| I | PURPOSE AND SCOPE | 1 |
| II | MODELLING THE RISK SYSTEM | 8 |
| | 1. System Description | 12 |
| | 2. Release Sequence Identification | 13 |
| | 3. Release Sequence Evaluation | 17 |
| | 4. Risk Calculation and Assessment | 20 |
| | 5. Summarizing the Risk | 22 |
| III | DANGEROUS COMMODITIES AND ACCIDENT LOCATION FACTORS | 30 |
| | 1. Area of Study | 31 |
| | 2. The Rail Network | 31 |
| | 3. Dangerous Commodities | 32 |
| | 4. Dangerous Commodity Flows | 39 |
| | 5. Accident Locations | 41 |
| | 6. Trans-shipment Points | 43 |
| | 7. Actions taken to Reduce Risk | 44 |
| | 8. Effects of Action Taken | 53 |
| IV | CONSEQUENCE FACTORS | 58 |
| | 1. Land Use and Population Density | 60 |
| | 2. Inner and Outer Zones | 61 |
| | 3. The Relative Risk Index | 62 |
| | 4. Other Consequence Factors | 71 |
| V | THE ACCIDENT RECORD | 72 |
| | 1. Accidents per mile of track | 74 |
| VI | RISK ASSESSMENT | 81 |
| APPENDIX TABLES A, B, C, D | | 86 |
| REFERENCES | | 100 |

## LIST OF FIGURES


| | | Following Page |
|---|---|---|
| 1. | Risk Spectrum for Propane Shipments by Rail Tank Car in 1985 (U.S.) | 9 |
| 2. | Risk Spectrum for Chlorine Shipments by Rail in 1985 (U.S.) | 9 |
| 3. | The Railway Network in the Toronto Census Metropolitan Area Showing Inspection Points and Hot Box Detectors | 31 |
| 4. | Rail Corridors and Population Density | 32 |
| 5. | Schematic Diagram of Routes with Dangerous Commodity Car Counts | 39 |
| 6. | Flow Chart of Dangerous Commodities - C.P. Rail | 39 |
| 7. | Flow Chart of Dangerous Commodities - C.N. Rail | 39 |
| 8. | Major and Minor Flows of Dangerous Commodities. All lines in Toronto CMA | 41 |
| 9. | Trans-shipment Points | 43 |
| 10. | The Rail Network and Population Density | 60 |
| 11. | Frequency of Corridors by Relative Risk Index - Inner Zone | 69 |
| 12. | Relative Risk Index by Corridors - Inner Zone | 70 |
| 13. | Relative Risk Index by Corridors - Outer Zone | 70 |

## LIST OF TABLES


| | | Page |
|---|---|---|
| 1. | Release Fractions Resulting from Failure of Tank Walls or Heads. Chlorine Tank Cars. | 19 |
| 2. | Probabilistic Chlorine Fatalities. | 24 |
| 3. | Chlorine Risk in Four Analyses. | 26 |
| 4. | Individual Risk from Various Accidents and Natural Disasters. (U.S.) | 28 |
| 5. | Twenty Most Frequently Transported Dangerous Commodities C.P. Rail 1980. | 34 |
| 6. | U.N. Dangerous Goods Class Schedule and Number of Special Dangerous Commodities. | 36 |
| 7. | Carloads of Dangerous Commodities. C.N. Rail. By Commodity Class. January to June 1982. | 37 |
| 8. | The Ten Most Frequently Transported Special Dangerous Commodities and other Dangerous Commodities C.N. Rail. | 38 |
| 9. | Dangerous Commodities and Population Density. Inner and Outer Zone. C.N.R. | 63 |
| 10. | Dangerous Commodities and Population Density. Inner and Outer Zone. C.P.R. | 67 |
| 11. | The Distribution of Corridors by Value of the Relative Risk Index. | 69 |
| 12. | National Summary of Railway Accidents 1974 - 1981. | 75 |
| 13. | Railway Accidents and Incidents Involving Dangerous Commodities 1974 - 81. | 76 |
| 14. | Types and Locations of Dangerous Commodity Accidents in 1981. | 77 |
| 15. | Expected Accidents on Main Line Track in Toronto C.M.A. 1981. | 78 |
| 16. | Expected and Recorded Accidents on Main Line in Toronto C.M.A. 1981. | 80 |

| | | Page |
|---|---|---|
| APPENDIX TABLE A. | Crossings and Track Data by Corridors - CNR | 86 |
| APPENDIX TABLE B. | Crossings and Track Data by Corridors - CPR | 90 |
| APPENDIX TABLE C. | Train Speeds and Inspection Procedures by Corridors - CNR | 93 |
| APPENDIX TABLE D. | Train Speeds and Inspection Procedures by Corridors - CPR | 97 |

## EXECUTIVE SUMMARY

1. This preliminary assessment of the risks of transporting dangerous commodities by rail in the Toronto Census Metropolitan Area is made in response to concern that new risks have been created without significant public knowledge or attention. The Mississauga train derailment and subsequent evacuation of November 1979, have stimulated this concern.

2. The purpose of the report is to make a preliminary assessment by examining the flows of dangerous commodities, the accident rates, and the exposure of people to possible releases of dangerous products.

3. Two main approaches to risk assessment are identified, a modelling approach and an historical/empirical approach. The strengths and weaknesses of each approach are described.

4. A modelling approach is described in detail in Section II drawing upon examples of studies on chlorine and propane conducted in the United States. These studies suggest that an accident involving chlorine and fire and product release might be expected to occur in the Toronto Census Metropolitan Area on average about once in a hundred years.

   The studies also show that the expected number of fatalities from accidental chlorine releases in the United States is 9.4 for the year 1985. The expected level of fatalities "predicted" the model for the period 1961 to 1978 in the United States is 86, or ten times the figure that actually occurred.

5. The probability of an individual being killed in the United States by an accidental release of chlorine from a rail tank car is 17 times less than the probability of being killed by a lightning strike and slightly higher than being killed on the ground by a crashing aircraft.

6. Volume of dangerous commodity flow is shown for the Toronto Census Metropolitan Area rail network. The pattern of major flows is described and shown on maps.

7. Various factors contributing to the probability of accidents are described and listed in tables, including crossings, track data, train speeds, and inspection points.

8. The location of trans-shipment points is mapped and indexed by class and volume of commodities.

9. Actions taken to reduce risks and the effect of those actions are described.

10. The relative degree of risk along different rail corridors is calculated by multiplying the volume of carloads of dangerous goods, by the population in inner and outer zones. The inner zone is a band .5 km. wide, centered on the track. The outer zone extends 1 km. on either side of the track for a total width of 2 km.

11. The relative risk index so calculated shows a much higher degree of risk along the Galt (part of) and North Toronto Subdivisions of CP Rail, than elsewhere in the City.

12. The Galt and North Toronto Subdivisions are lacking in trans-shipment points for dangerous commodities.

13. In the event of an accident and a major release of dangerous commodities in a densely populated area, such as the Galt or North Toronto Subdivisions, there exists the possibility of hundreds of fatalities or more. Detailed analysis of possible consequences has not been carried out. If this were to be done on a commodity-by-commodity basis, it might not change the risk assessment significantly, but it would be useful for emergency planning purposes.

14. The national accident record is examined for the period 1974-81. The total number of railway accidents is down, but the number of accidents involving dangerous commodities shows a marked increase. This is due in large part to more complete reporting since 1980.

15. On the basis of national accident statistics, and considering the miles of main line track in Toronto, it is estimated that about 2 accidents involving dangerous goods may be expected per year. In 1981, there were 3 accidents (all derailments) or 5, if the two collisions in the Oakville Yard are included.

16. On the same basis, it is estimated that an accident resulting in the release of a dangerous commodity can be expected to occur in Toronto an average once in every 5 to 10 years. No accidental releases were recorded in 1981.

## RECOMMENDATIONS

1. It is recommended that consideration be given to diverting the flow of special dangerous commodities off the Galt and North Toronto Subdivisions of CP Rail, and rerouting them along the York Subdivision of C.N.R., such rerouting will require the making of some new connections between CN and CP tracks. The feasibility of this rerouting should be examined as a matter of urgency by the Canadian National and Canadian Pacific Railways.

2. The rerouting of special dangerous commodities would substantially reduce the present level of risk, but it is only a palliative and temporary measure. It is suggested that the interested parties initiate an examination of the possibility of railway relocation so that new routes may be provided to permit the transport of dangerous commodities around population centres.

# I PURPOSE AND SCOPE

The purpose of this study is to make a preliminary investigation of the transport of dangerous commodities by rail in the Toronto region, in order to ascertain the nature of the risks that exist and to provide a basis for judgements concerning the seriousness of the risk.

There are two fundamental approaches to the quantitative assessment of risk. First, we may rely on past experience to provide a statistical basis for what may be expected in the future. This is termed the historical or empirical approach. Second, we may construct a risk assessment model which simulates the operation of the system as it now is.

The historical/empirical approach keeps us firmly grounded in the evidence of real events. Its major deficiency is that the system may be changing and new risks may now exist that were not previously present. The past may not be a good guide to the future.

The risk assessment modelling approach is subject to the errors that may be introduced by abstraction and theorizing. In order to make the analysis tractable, simplifying assumptions have to be made. Although the formal modelling process helps, the identification of possible accidents relies, in part, upon the exercise of human imagination. What is most difficult about the modelling approach is that it requires predictions or assumptions to be made about human behaviour -- a notoriously hazardous procedure.

The modelling approach has the great advantage over the historical approach, that it deals or attempts to deal with the risks in the system as they are rather than how they have been. Its great disadvantage can be summarized by saying that the models may not be a very close approximation to reality.

In ideal circumstances, an obvious response would be to utilize both approaches and to compare their results. Indeed, in view of the obvious weaknesses of both methods, this is the most sensible response. This strategy is complicated however by the fact that the modelling approach is time-consuming and therefore costly. Since a quick response to the concerns of the public about the risks of transporting dangerous commodities by rail is needed, this report is confined largely to the historical/empirical approach. A description of a possible modelling approach is provided in some detail in Section II.

The historical approach can, by itself, give some order of magnitude idea about the degree of risk involved. It does not necessarily follow that future risk is greater or less than past risk. A larger number of dangerous commodities, travelling through densely populated areas, in larger quantities, and including more lethal materials may suggest increased risk. By the same token, new technology in railroad and car design and new more strict and safer operating procedures may suggest lower risk. The balance is not clear.

The historical approach can be tempered by the utilization of expert knowledge and judgment about how past risks are being changed and this, itself, may provide a sufficient basis for decision and action in some cases.

Without a modelling approach the area of uncertainty will remain large. With the addition of a modelling approach, the uncertainty will be reduced but not eliminated.

There is no secrecy about the reasons for the preparation of such a study at this time. In November 1979, the derailment of a Canadian Pacific train at the Mavis Road crossing in Mississauga, Ontario was accompanied by explosions* and fires, together with the leakage of chlorine gas. Prudence required the evacuation of about 225,000 residents and the resulting economic losses have been conservatively estimated at $68.7 million (Burton, Victor and Whtye, 1981). The public concern generated by this accident was reinforced on February 28, 1982 by another derailment in Medonte Township near Orillia, Ontario which involved the evacuation of approximately one thousand people in a much more sparsely populated area.

Fears that the consequences of these accidents could have been much more serious than they proved to be, have led to the recognition of a need to know more about the risks that are involved and how much danger, in fact, exists.

The nature of the problem can be stated very simply. There are trains carrying dangerous commodities through some of the most densely populated parts of the city. In the event of an accident, resulting in the release of one or more of these commodities, the lives of people in the vicinity could be jeopardized. Since the Mississauga derailment, it has become widely recognized that in the worst possible circumstance the number of people at risk could be very large indeed. The possibility that hundreds, or perhaps even larger

* The word "explosion" is used in this report as a general term; the Mississauga accident did not involve explosions in the chemical technical sense of the word.

numbers, of people could be killed by a railway accident occurring in a Canadian City has come as a startling revelation to many people. The public are entitled to ask how such a situation has come about and what might be done about it.

The answer seems to lie in the steady growth of some factors that contribute to the risk, although these have not been precisely measured. With industrial development and innovations in technology, there are more trains carrying more dangerous commodities in larger quantities than before. Of particular note, is the increase in the number of dangerous chemicals including toxic substances. At the same time, improvements in railway construction and the design of rolling stock have made possible the transport of these materials with relatively few serious accidents so far.

Nevertheless, the possibility of serious a c c i d e n t s d o e s exist as was demonstrated at Mississauga in 1979. When accidents do occur, there is a greater likelihood that people will be affected because cities have expanded and population has increased in areas adjacent to railway tracks.

One possible course of action might be to keep people at a safe distance from the railways where dangerous goods are being transported. There are reasons why, up to now, this has not happened. Railways transport goods between cities and inevitably their routes lead them into centres of population. Railways were not, in the past, perceived as being as dangerous as they now are and so,

in the face of pressures for the development of urban land, municipal governments have permitted development, including residential development, to expand very close to the pre-existing railway lines. This process continues today. The new Canadian National line (the York Subdivision) running north of Steeles Avenue just beyond the boundary of Metropolitan Toronto passed largely through open land and fields when it was opened in 1964. Today, it passes through modern suburbs. While residential density in those suburbs is not as great as in some of the older sections of the city, it illustrates that the factors contributing to risk are still operating.

Given that risks are clearly seen to exist, and given a degree of public concern and anxiety about the risks, it makes sense to try to ascertain something about the magnitude of the risks and the possibilities for reducing them.

In so doing, society is seeking to achieve a reasonable balance between the degree of risk and the cost of risk reduction. Almost any risk can be reduced by the expenditure of sufficient funds. The question always to be asked therefore is, does the level of risk seem sufficiently high to merit further attempts at risk reduction and, if so, how much risk reduction is to be sought, and at what cost, given that there are competing claims on the "risk reduction" dollars?

This question cannot be fully addressed without reference to different kinds of risk. In the railway context we should also ask where the priorities lie. For example how important are the risks associated with the transport of dangerous commodities compared with the risks at level crossings?

In order to make any judgements about this problem, we need to know what dangerous goods are involved, in what quantities, and what routes these goods move along. Further, we need to know what the chances are of any one of the cargoes becoming involved in an accident which leads to an escape of dangerous substances or to an accident sequence which may endanger people exposed to it. We shall also need to know how many people are likely to be exposed along the route and what the consequences might be for them. To attempt any definitive study of the risks associated with the transportation of dangerous goods is thus a large task. Within the scope of this preliminary study, the task has had to be severely circumscribed.

First, the scope of this study is limited to railway accidents on main tracks, within the Toronto Census Metropolitan Area which involve dangerous commodities. Thus, several areas of risk are excluded at the outset. These include railway accidents involving passenger trains only or freight trains in which no dangerous commodities are present. Also excluded are accidents involving dangerous commodities in use or in storage adjacent to railways, which may be affected by train accidents. The transport of dangerous commodities by other means (road, air, water, pipeline) are likewise excluded from consideration here.

The risk of handling dangerous commodities in railway marshalling yards and at trans-shipment points are part of the problem of the transport of dangerous goods by rail, but it is generally thought that <u>major</u> accidents are less likely in marshalling yards because speeds are usually very slow. In particular,

this reduces the likelihood of rupture leading to leakage and the quantity of commodities handled at any single trans-shipment point at one time is usually small. Partly for these reasons, and partly because public interest currently centres on the movement of dangerous commodities at speed through urban areas, this study focusses mainly on the latter, while not totally excluding consideration of risks within marshalling yards and at trans-shipment points. That dangers exist in marshalling yards is exemplified by the recent collision in the CP Yards at Winnipeg where an "empty" propane car exploded. This accident is currently under investigation by the RTC.

A more complete study should include an assessment of all these risks as well as consideration of alternative modes of transportation in some instances.

No detailed methodology has been yet developed for a study of risks associated with rail transport in an urban region. Methodologies for risk assessment have been developed for site-specific risks, e.g. accidents at nuclear generation stations (Reactor Safety Study 1975), for railway accidents in a specific location (Dakers 1982), and for transport risks over a whole national territory (Arthur D. Little Inc. 1974). In the next section methodology for modelling transport risks is described and the examples of propane and chlorine are used for purposes of illustration. Both propane and chlorine were involved in the Mississauga accident.

## II MODELLING THE RISK SYSTEM

The basic definition of risk used in this study, and now widely accepted in the risk assessment community, is that a risk is the probability of an event multiplied by its consequences. This may be expressed as:

Risk = Pr(E) x Consequences.

The process of risk estimation, therefore, involves a calculation of the probability of certain events over a specified period of time in a defined area. The probability estimate is then related to the expected consequences.

The risks associated with the transport of dangerous commodities therefore involve the probability of such commodities being involved in accidents that will cause them to leak or escape from their containment. Further, the escaping commodities must then come into contact with human populations, either directly or indirectly, in order to cause them harm.

Scientific or technical risk assessment is a formal and quantitative approach to the estimation and evaluation of risk. As such, it seeks to be objective and specifically tries to exclude the value judgments or opinions of the risk analyst. In this, it differs from risk perception where value judgments are inextricably involved. We shall have occasion later to refer again to the differences between formal risk assessment and risk perception.

A number of risk assessments have been carried out in the United States on the transportation of dangerous commodities (McSweeney and Hall 1975). These studies each focus on the risk of a single commodity in a national context and over the total area of the United States. Some of them deal with more than one mode of transport.

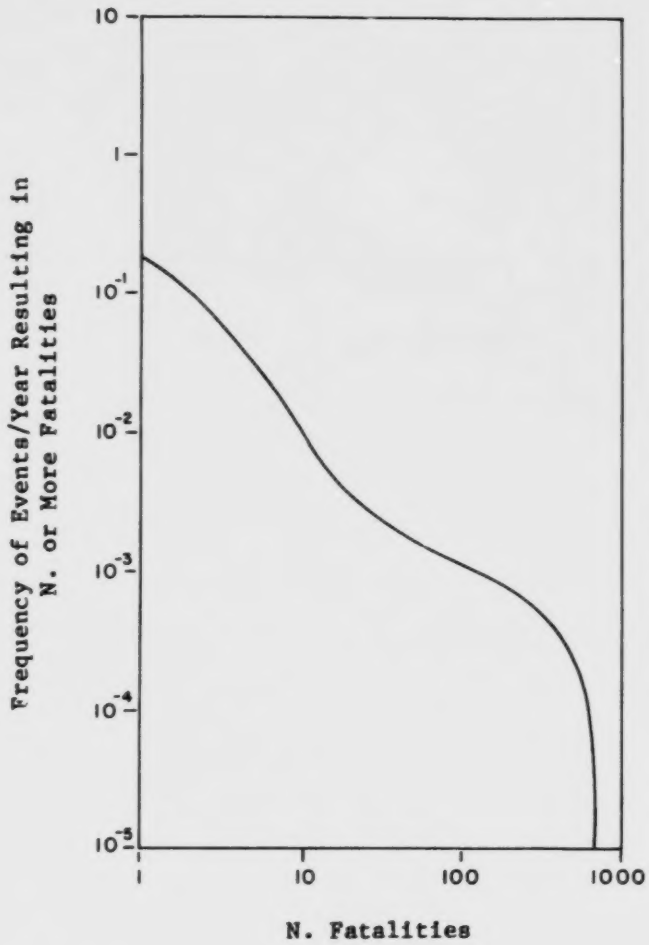
The results are expressed in two forms. First, an estimate is produced of the total expected number of fatalities per year (for a specific future year). In the case of propane transport, for example, it is estimated that the number of fatalities caused by transporting propane by road and rail in 1985 will be 15. This represents an individual risk of death to each person in the United States of 1 in 15 million per year. (Geffen 1980). Of the 15 expected fatalities only .5 (equivalent to one fatality every 2 years) stems from the movement of propane in rail tank cars.

The second form of result is a graph showing the risk spectrum for propane shipments in 1985. This indicates the estimated frequency in events per year resulting in N or more fatalities. The risk spectrum for propane rail tank car accidents is shown in Figure 1. Thus, the risk of an event resulting in one fatality is less than $10^{-1}$ or one chance in 10. The risk of an event causing 100 or more fatalities is about $10^{-3}$ or a probability of .001 (one chance in a thousand).

In a similar study for chlorine (Andrews 1980), it is estimated that the number of fatalities caused by transporting chlorine by rail in 1985 will be 9.4. This represents an individual risk of death to each person in the United States of 1 in 22,300,000 per year. The risk spectrum for chlorine is shown in Figure 2. Note that the risk spectrum for both chlorine and propane levels off as it approaches 1,000 fatalities per event.

Figure 1

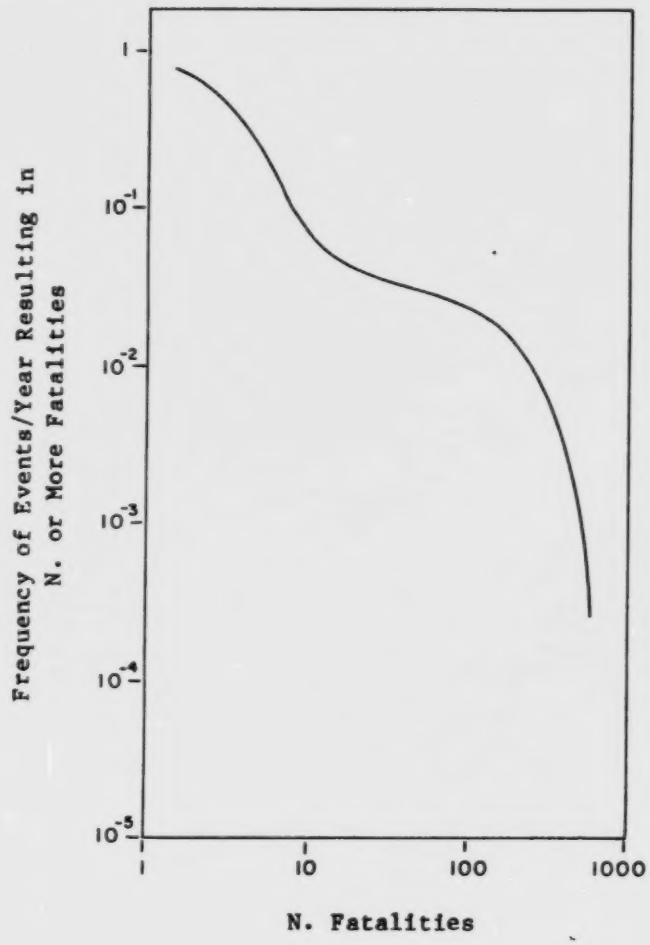
RISK SPECTRUM FOR PROPANE
SHIPMENTS BY RAIL TANK CAR
IN 1985 (U.S.)




Source: Pacific Northwest Laboratory 1980

Figure 2

RISK SPECTRUM FOR CHLORINE
SHIPMENTS BY RAIL IN 1985 (U.S.)




Source: Pacific Northwest Laboratory 1980

As will be seen later, to proceed to model risks in transport on a commodity-by-commodity basis is an extremely time-consuming process. The main reason why modelling studies have to focus upon one single commodity at a time is that the estimation of accident probabilities depends upon the railway rolling stock used, and the estimate of consequences of an accidental release depends on the nature of the commodity released. Given a very similar type of accident, the consequences can be very different if radioactive material is released compared with chlorine gas or propane.

An outline is now given of the methodology by which these estimates were obtained. The methodology has been developed in a series of studies undertaken at the Pacific Northwest Laboratory in Richland, Washington.

The method uses the basic risk definition expressed as:

$$R = \sum_i R_i$$

The total risk in the system R (e.g. rail transport of chlorine) is the sum of the risks of all accidental releases denoted as subscript i. Any individual release (one of the i's) is calculated as the product of the probability of its occurrence and the consequences of the release. In other words, the total risk is the sum of many separable risks. The analysis is based on the assumption that all accidents are independent events. That is to say that the occurrence of one accident does not in any way affect the probability of other accidents. The assumption is not valid and to a degree this may account for the divergence of model results from reality.

The development of a model involves the selection of variables to use in the probability times consequences equation. A basic model, developed by the Pacific Northwest Laboratory (PNL) for propane transport, has the following form:

$$R, = ({}^{P}Qi \times Pi) \quad X\sum \quad ({}^{C}Q_{i,q} \times Pq)$$

The first expression ${}^{P}Qi \times Pi$ is the probability term. Qi represents the amount of material released in the $i^{th}$ release sequence. The second factor Pi represents the probability of release of this quantity of material during transport. In other words, for $R, = ({}^{P}Qi \times Pi) \times \sum_{q} ({}^{C}Qiq \times Pq)$ a given commodity (in this case propane), we need to know the probability of each level or quantity of material released. (Geffen 1980).

The second expression is the consequence term. It includes only two variables, population density and weather conditions. The consequences, C, of a given release, Qi, depend upon the population density and the weather conditions obtained at the time of the release, q. The joint probability of a particular set of weather conditions, within a specific population zone, are expressed as Pq.

The model thus involves only the probability of release of specific quantities of the material being transported and the joint probability of population density and weather conditions. This is a highly simplified version of the long list of factors that are involved in the measurement of consequences as described in Section IV Consequence Factors.

Nevertheless, the data requirements for the modelling exercise are considerable. Four sets of data or data components are required as follows:

- system description
- release sequence identification
- release sequence evaluation
- risk calculation and assessment

They are each described, in turn, to give an impression of the scale of the undertaking in a modelling study and the strengths and limitations of the approach.

1. System description

The first set of data required relates to the basic properties of the system under study. In the PNL model, there are seven items as follows:

- industry characteristics

  the years under study, the boundaries of what is in the system and what is excluded,

- amount of commodity, origin and destination

  total quantity carried, from which points or origin (e.g. chlorine plant) to which points of destination (e.g. water works, paper mill) and what routes,

- characteristics of material

  e.g. liquid chlorine, equivalent in gaseous form, lighter or heavier than air, diffusion process, lethal dose or concentration,

- transport mode, carrier, and regulations
  e.g. rail, CNR or CPR, requirement or tank car specifications,
- container and container properties
  e.g. 90 ton tank car, with or without head shield, etc.,
- number of shipments expected or required
  calculated from historic trends, total output, estimates of future demand,
- route, population and weather zones
- size of shipments, density and proximity of population along routes, probability of various specified weather conditions en route.

2. Release sequence identification

A leakage of a dangerous commodity results not from a single event but from a sequence of events. These sequences can be broken down into their component parts and the probability of each estimated.

A description of the release sequence in the Mississauga accident can be derived from the testimony of the Grange Inquiry as follows:

lubrication pad in journal box of tank car of toluene fails or dries out (insufficient lubrication) - journal overheats (the "hot box") - journal burns through - rear axle assembly at right rear of the car drops - entire axle detached from car - car trails along tracks supported by the front two sets of

wheels and the one remaining lead set of rear wheels - the toluene tank car derails at a rail frog just west of the Mavis Road crossing and takes 23 other cars off the track with it, including cars of propane and one filled with 90 tons of chlorine - a series of explosions occur in the propane cars - metal flies in all directions - the chlorine tank car is breached and the chlorine begins to escape (the exact cause is not known, the chlorine car could have been damaged by the impact of the derailment, by the explosions, or by the heat from the fires causing a corrosive action inside the tank car, or a combination of these factors) - a quantity of chlorine gas escapes but is rapidly dispersed into the upper air by the strong convection draft created by the burning propane and toluene ..... and so on.

In this case, the release sequence continued for several days until it became possible to apply a patch to the hole in the chlorine tank car.

The purpose of release sequence identification is to list all the possible ways in which an accidental release of a given quantity, of a given material, may be released at a given rate. There are four approaches to the identification of release sequences as follows:

- historical data or experience

  sequences of events or their variants are identified from analyses of what actually happened in recorded accidents. The foregoing release sequence from Mississauga is an example,

- direct postulation

  sequences of events are imagined and described by experienced analysts who examine the system and suggest where and how accidents may occur drawing upon experience and judgement,

- fault tree analysis

  an approach that assumes that an undesirable event has occurred (e.g. 20 tons of chlorine escapes from a tank car) and works backwards from this event to identify the sequences of events that could cause this to happen. Fault tree analysis is a formalized way of organizing this deductive approach,

- event tree analysis

  an approach in which the failure of specific system components is envisaged and a sequence of succeeding events is followed leading, in some instances, to system failure. For example, the analysis might begin with the assumption that a journal overheats and proceeds by asking what could happen next, and next .....

In these ways, descriptions are built up of many possible release sequences. The probability of each is estimated from experience in the industry (how often do journals overheat?) or from the basic data of materials science (what impact is required to breach a tank car of specified design and strength?).

As can be seen from the release sequence description, for the Mississauga accident, there is almost no limit to the amount of detail that may be involved. Indeed, much more precise information might be developed at each stage of the sequence. What were the steps that led to "insufficient lubrication"? Just what process is involved when a journal "burns through"? And so forth.

When the process of release sequence identification proceeds by fault-tree analysis, as in the PNL study, it is common practice to look at the failure of large component sub-systems only - not in the most excruciating detail that is theoretically possible. This is known as a Top Level Fault Tree.

The PNL study of chlorine transport identifies 103 possible release sequences in a top level fault tree. As far as can be ascertained the Mississauga release sequence is not identified as one of these sequences.

This is an experience with fault-tree analysis that has occurred previously. The fault tree identifies many possible accident sequences but, nevertheless, accidents occur which were not anticipated or imagined by the analysts.

3. Release sequence evaluation

The probability of each component of the release sequences identified is then estimated. The probability of any one sequence occurring is the product of its component probabilities.

In the PNL study, for example, the probability of a transport accident is estimated at $2.8 \times 10^{-3}$ per shipment. This is derived from the overall accident rate which is reported to be (for American railroads) an accident once every $1.6 \times 10^{5}$ km, that is a rate of $6.25 \times 10^{-6}$ rail accidents per kilometer. The average loaded shipping distance for chlorine tank cars (again in the U.S.) is estimated to be 450 km. For this shipping distance the expected accident frequency works out at $2.8 \times 10^{-3}$ accidents per shipment. In other words, a probability of .0028.

Analysis of data from collisions and derailment accidents indicates that fire occurs in approximately $1.6 \times 10^{-2}$ of those accidents. It is further estimated in the PNL study that 14% of these fires would involve a chlorine tank car. A value of $2.3 \times 10^{-3}$ is derived.

Given an accident involving a chlorine tank car, and given a fire, what are the chances that the fire will be sufficient to overpressurize tank walls weakened by accident forces? The probability estimated in the PNL study is 0.42. But what if the tank walls were not weakened by the accident forces? And so forth.

These U.S. analyses suggest that for all shipments there is a probability of $4.5 \times 10^{-5}$ of accident and fire. If the probability of the tank being a chlorine tank car is added the chance of it being involved in an accident and fire are $6.3 \times 10^{-6}$ (or .0000063) per shipment. This is one chance in 158,730 or approximately 6 chances in a million. These calculations are for U.S. conditions, volume of chlorine transported and so on, but they do suggest the order of magnitude of the likelihood of the Mississauga accident. It was a rare event. But as we shall see, a rare event with potentially serious consequences.

By this methodology a series of contingent probability estimates is made and multiplied together to give the overall probability for each release sequence that has been identified.

This procedure is followed up to the point of estimating the probability of release of specific quantities or proportions of the dangerous cargo. In the case of chlorine tank cars in the U.S., four causes are identified for the failure of tank walls or heads (as in Mississauga). These and their associated release fractions are listed in Table 1.

TABLE 1 RELEASE FRACTIONS RESULTING FROM FAILURE OF TANK WALLS OR HEADS. CHLORINE TANK CARS

| Cause | Release Fraction |
|---|---|
| Puncture | 17% |
| Crush | 17% |
| Impact | 17% |
| Fire | 32% |

Source: Andrews, W.B.; Pacific Northwest Laboratories. 1980.

However, the assignment of a release to one of these four causes is necessarily somewhat arbitrary and this limits the usefulness of such estimates of release fractions in risk analysis. Whatever the cause may have been in Mississauga, only 10 out of the 90 tons of chlorine remained in the tank car when emergency workers could eventually reach it. The release fraction was 89%!

4. Risk Calculation and Assessment

Once the quantity of dangerous commodities released (and the probability of each size class of release) has been estimated, calculations are required of the likely impact on human populations.

At this stage, five more sub-models are required.

These are:

- health data, specifically a dose/response relationship describing levels of expected fatalities at various levels of concentration (of chlorine);

- weather data, including a model of the frequency with which various weather conditions can be expected in study areas or localities;

- population data, including a model of the expected density of population;

- evacuation data, including a model of the rate at which people can be evacuated from the areas of lethal concentration;

- dispersion data, including the paths by which the dangerous cargoes can reach their "target" human populations. In the case of chlorine gas only atmospheric dispersion data is needed but in other instances food chain and aquatic pathways are also involved.

These data and models are then combined into an estimate of exposure frequency. This "consequence analysis" is then used to derive probabilistic consequences of chlorine releases.

The results from the PNL study are listed on Table 2. These estimates include an important distinction between a continuous release of chlorine in a steady stream and a sudden rapid release or puff. It is assumed that in the case of Mississauga a "puff release" occurred presumably higher than 32%. At the 32% level there is more than a 2% chance of 100 fatalities and more than one in a thousand chance of 630 fatalities.

It is dangerous, perhaps, to make too much out of such figures without going into the considerable detail involved in the consequence analysis. For example, the study assumes an effective level of evacuation such that only one in ten residents would be killed in the cloud area with a concentration of 1,000 parts per million of chlorine gas. (1,000 ppm can be assumed to be immediately fatal). In other words, 90% of the population in the area to be covered by the cloud are assumed to have been evacuated before the concentration reaches 1,000 ppm. In a densely populated urban area it is probably an unrealistic assumption.

5. Summarizing the Risk

Upon completion of the modelling exercise described, the findings can be presented in a form to facilitate an evaluation of the risk by decision-makers and/or by those at risk.

This takes the form of estimates of expected fatalities and a graph of the risk spectrum. As noted above, the predicted number of deaths in 1985 from chlorine releases was 9.4. The risk spectrum is shown in Figure 2.

Considerable time and cost is involved in arriving at these estimates. What do they suggest about the value of a modelling approach to risk assessment and how can they be used by decision-makers?

Six comments are appropriate at this point in assessing the value of a modelling approach in the context of risk in the Toronto Census Metropolitan Area.

- comparison with historical data

The risks predicted in the PNL study are higher than those predicted by available historical accident data. Chlorine Institute data indicates that nine large releases of chlorine have occurred (in the U.S.) since 1935. Only two have resulted in fatalities. The first was in 1961 when thirty tons were lost

resulting in one fatality. The second fatal accident was in February 1978 and resulted in 8 deaths. Using the model developed in the PNL study and applying it to shipment volumes recorded, some 86 deaths are "predicted" for the period 1961 to 1978, or ten times the figure that actually occurred historically. The factor could be much higher if a larger period of record were selected.

- comparison to other risk estimates

The use of similar models and the expression of results in common terms permits comparison of risk estimates in other studies in other countries to be made as shown in Table 3.

There are some significant differences between the U.S. rail system, on the one hand, and the Finnish and British on the other. For example, the latter uses the European 30-ton chlorine tank cars instead of the 90-ton model in use in the U.S. and Canada. Nevertheless, results serve to indicate a range of probability estimates and suggest the degree of uncertainty involved.

TABLE 2

PROBABILISTIC CHLORINE FATALITIES

| Deaths (N) | Probability of conditions which result in N or more fatalities given that a chlorine release occurs. | | | |
|---|---|---|---|---|
| | Release Size | | | |
| | 3.9 kg/sec. | 9.8 kg/sec. | 17.5% Puff | 32% Puff |
| 1 | 0.21 | 0.51 | 0.82 | 0.94 |
| 4 | 0.039 | 0.18 | 0.30 | 0.50 |
| 10 | 0.024 | 0.11 | 0.036 | 0.11 |
| 25 | 0.014 | 0.027 | 0.030 | 0.031 |
| 63 | $6.3 \times 10^{-3}$ | 0.018 | 0.024 | 0.028 |
| 100 | $4.9 \times 10^{-3}$ | 0.013 | 0.019 | 0.023 |
| 250 | $5.57 \times 10^{-4}$ | $5.1 \times 10^{-3}$ | $6.3 \times 10^{-3}$ | 0.015 |
| 630 | 0 | $5.4 \times 10^{-4}$ | 0 | $1.6 \times 10^{-3}$ |
| 1000 | - | 0 | - | 0 |

Source: Andrews, W.B., Pacific Northwest Laboratory, 1980.

- extreme events excluded

An extremely significant comment in the PNL study is that, "it was not possible to determine the shape of the risk curve for events producing more than 1,000 fatalities". Such estimates could in fact be made but probably with very wide error margins.

Nor, from the perspective of formal risk analysis, does it much matter. The contribution to the expected value of fatalities of an accident causing 600 deaths at a probability of $10^{-4}$ is .06. The contribution to the expected value of fatalities of an accident causing 60 deaths at a probability of $10^{-1}$ is 6. In other words, the accidents of lesser consequence but higher probability are more important in the summation of overall risk.

- relation to public perception

Studies of public perception of risk show that people are much less impressed by probability than by consequence, especially high consequences. (Whyte and Burton 1982). Thus, one accident involving 600 fatalities is likely to seem far more threatening and unacceptable to people than six hundred accidents causing one fatality each. This is true both in retrospect and in prospect. Public concern can, therefore, be expected to manifest itself whenever high consequences are described almost regardless of probabilities.

TABLE 3

CHLORINE RISK IN FOUR ANALYSES

| Study | Risk deaths per ton/mile of liquid chlorine transport |
|---|---|
| Finland. Lautkaski and Mankamo 1976 | $5.9 \times 10^{-8}$ |
| U.S.A. Simmons, Erdmann and Naft 1974 | $1.5 \times 10^{-8}$ |
| U.S.A. P.N.L. Study (Andrews 1980) | $6.8 \times 10^{-9}$ |
| U.K. Westbrook 1974 | $2.5 \times 10^{-10}$ |

Source: Andrews, W.B. Pacific Northwest Laboratory 1980

- relation to other risks

A commonly used format for attempting to put risks in perspective is to compare dissimilar risks in terms of their total fatalities. Individual risks from various accidents and natural hazards are compared in Table 4. This table shows that for the U.S. the individual risk from the transport of chlorine by rail is seventeen times less than the risk of being struck by lightning and slightly greater than a person on the ground being killed by a crashing aircraft (U.S. data). This comparison is itself based on an estimated number of chlorine deaths in 1985, while as we have seen it is at least ten times higher than the historical record.

- sensitivity analysis

One potentially valuable use for the modelling approach is that the risk spectrum can be tested for sensitivity to variation in system parameters. For example, in the PNL study of chlorine the installation of head shields on all chlorine tank cars results (in the model) in a reduction in the expected fatalities from 9.4 to 9.0. While these reductions in expected fatalities are smaller, changes in chlorine tank car design may increase the probability of a derailment through adverse train-track dynamics.

The discussion of the modelling approach which has been developed in some detail provides a useful base for comparison in the development of an historical approach to risk for the Toronto Census Metropolitan Area. It is also a guide to the data which would be needed for any further risk assessment.

TABLE 4

INDIVIDUAL RISK FROM VARIOUS ACCIDENTS AND NATURAL DISASTERS (U.S.)

| Accident Type | Total Fatalities | Individual Risk per Year |
|---|---|---|
| All Accidents | 115,821 | 1 in 2,000 |
| Motor Vehicls Accidents | 55,511 | 1 in 4,000 |
| All Industrial Accidents | 14,100 | 1 in 6,000 |
| Falls | 16,506 | 1 in 13,000 |
| Drowning | 7,152 | 1 in 29,000 |
| Fires | 6,503 | 1 in 32,000 |
| Poisoning | 5,335 | 1 in 40,000 |
| Airplane Crashes | 1,668 | 1 in 130,000 |
| Railway Accidents(all railway accidents) | 789 | 1 in 250,000 |
| Lightning | 160 | 1 in 1,300,000 |
| Tornadoes | 90 | 1 in 2,300,000 |
| Dam Failures | 35 | 1 in 5,700,000 |
| Gasoline Tank Truck Accidents | 28 | 1 in 7,400,000 |
| Propane Transportation Accidents | 15 | 1 in 15,000,000 |
| Chlorine Rail Car Accidents | 9.4 | 1 in 22,300,000 |
| Air Crashes (persons on ground) | 6 | 1 in 33,000,000 |

Source: Andrews, W.B. Pacific Northwest Laboratory 1980.
Various dates for fatality estimates 1980 - 85.

The assumptions and definitions of accidents vary somewhat. The comparisons are not therefore precise but give an order of magnitude indication of comparative risk.

The method is based on a commodity-by-commodity approach which yields national estimates of risk, but tells nothing about where accidents are likely to occur or what the risk is to particular communities. For the purposes of the present study in Toronto an overview of risks from all dangerous commodities is needed. This will be approached from an empirical perspective, looking at all dangerous commodities, tempered where appropriate by reference to the modelling approach and studies discussed in this section. For a more precise estimate of risk, studies on a commodity-by commodity basis are necessary. Given the uncertainties of the analysis however, there is no great merit in giving an appearance of precision for the sake of precision.

## III DANGEROUS COMMODITIES AND ACCIDENT LOCATION: FACTORS IN THE PROBABILITY OF ACCIDENTS

In order to obtain a broad picture of the risks from the transport of dangerous commodities in the Toronto region, it is necessary to limit the study to manageable proportions. The section deals with the definition and description of a series of risk factors. These are:

- the area of study

  definition of its extent

- the rail network

  the pattern and number of railway lines

- the dangerous commodities

  types of dangerous commodities

- the dangerous commodity flows

  the quantities carried and the routes over which they move

- accident locations

  risk factors affecting where accidents might occur

- trans-shipment points

  points of risk where commodities are loaded or unloaded

- actions taken to reduce risk

In each case the definition adopted is followed by a description of the data available and wherever practicable this is organized in the form of maps or tables so that the basic facts of volumes and flows can be appreciated. This says nothing about degree of risk but it does help to identify where the risks are located.

## 1. Area of study

The area of study has been defined as the Census Metropolitan Area of Toronto. The boundaries of the CMA are shown on Figure 3. An area somewhat larger than that of the Municipality of Metropolitan Toronto has been chosen. This is because dense urban patterns of settlement extend beyond the boundaries of Metropolitan Toronto. This has been recognized by the Railway Transport Committee in the establishment of "gateway inspection points" near the boundaries of the Census Metropolitan Area.

## 2. The rail network

The rail network within the CMA is also shown on Figure 3. It consists of the main passenger and freight routes of the Canadian National Railway (CN) and the Canadian Pacific Railway (CP) and also some tracks in the vicinity of Union Station in downtown Toronto that are jointly operated by CN and CP and which are referred to as the Toronto Terminal Railway.

C.M.A. mi. 34.6

C.M.A. mi. 32.5

L. Belwood

County of Dufferin

County of Wellington

C.P. Rail

Orangeville

Elora

Fergus

Guelph Junction

Milton

Campbellville

Acton

Georgetown

Norval

Terra Cotta

Inglewood

Palgrave

Bolton

Woodbridge

Kleinburg

Nashville

Pickering

Whitby

Oshawa

Port Perry

Lindsay

Peterborough

Barrie

Orillia

Parry Sound

Owen Sound

Highway 6

Highway 7

Highway 9

Highway 10

Highway 24

Highway 25

Highway 27

Highway 28

Highway 30

Highway 35

Highway 48

Highway 50

Highway 89

Highway 400

TOWN OF CALEDON

TOWNSHIP OF KING

Peel

York

H.B.D.

GATEWAY INSPECTION mi. 26.4

GATEWAY M INSPECTION mi. 17.1

GATEWAY INSPECTION mi. 25.0

Manual inspection if train is not in 15 m.p.h. must be exceeded

CITY OF GUELPH

County of Wellington

County of Halton

County of Wellington

CN Guelph Sub.

CP Orangeville Sub.

CN Halton Sub.

CP MacTier Sub.

CN Weston Sub.

CN York Sub.

C.M.A. mi. 20.7

H.B.D. mi. 18.0

mi. 21.0

mi. 17.0

M mi. 7.9

mi. 12.1 Newmarket

mi. 18 Bala

mi. 23.6 York

TOWN OF HALTON HILLS

CITY OF BRAMPTON

TOWN OF VAUGHAN

METROPOLITAN TORONTO

PUSLINCH

Steeles Ave.

Hwy. 400

Lake Simcoe

TOWNSHIP OF GEORGINA

TOWNSHIP OF EAST GWILLIMBURY

TOWN OF CALEDON

TOWNSHIP OF KING

TOWN OF NEWMARKET

TOWN OF AURORA

TOWN OF WHITCHURCH-STOUFFVILLE

TOWN OF RICHMOND HILL

TOWN OF VAUGHAN

TOWN OF MARKHAM

TOWNSHIP OF UXBRIDGE

TOWN OF PICKERING

TOWN OF WHITBY

GATEWAY INSPECTION mi. 41.0

C.M.A. mi. 32.5

C.M.A. mi. 40.4

C.M.A. mi. 43.4

GATEWAY INSPECTION mi. 26.4

H.B.D.

mi. 31.0

Manual inspection limits
If train is not inspected
15 m.p.h. must not be
exceeded

mi. 21.0

CN Bala Sub

mi. 31.2

H.B.D.

mi. 28.4

GATEWAY M INSPECTION mi. 35.0

Hwy 47

C.M.A. mi. 39.0

Peel

York

Durham

Hwy 400

CP MacTier Sub

CP Orangeville Sub

CN Uxbridge Sub

CP Havelock Sub

H.B.D.

M mi. 7.8

mi. 12.1 Newmarket

mi. 16 Bala

mi. 18 York

mi. 50.9

mi. 23.6 York

CN York Sub

CN Newmarket Sub

CN Weston Sub

Steeles Ave.

METROPOLITAN TORONTO

mi. 14.0

Manual

C.M.A. Toronto mi. 181.33

M mi. 158.0

Lake Simcoe

TOWNSHIP OF GEORGINA

TOWNSHIP OF EAST GWILLIMBURY

TOWNSHIP OF BROCK

TOWNSHIP OF UXBRIDGE

TOWN OF NEWMARKET

TOWN OF AURORA

TOWN OF WHITCHURCH-STOUFFVILLE

TOWN OF RICHMOND HILL

TOWN OF MARKHAM

TOWN OF PICKERING

TOWN OF WHITBY

CITY

TOWNSHIP OF SCUGOG

LAKE SCUGOG

GATEWAY INSPECTION mi.41.0

C.M.A. mi.40.4

C.M.A. mi.43.4

mi.31.0

mi.31.2 H.B.D.

mi.28.4

GATEWAY M INSPECTION mi.35.0

C.M.A. mi.39.0

mi.50.9

mi.14.0

C.M.A. Toronto mi.161.33

M mi.158.0

CN Bala Sub.

CN Uxbridge Sub.

CP Havelock Sub.

Hwy 47

Highway 48

Highway 12

Highway 7A

Highway 35

Proposed Highway 404

York Durham Line

County of Victoria

**LEGEND**

- Hot Box Detector
- Interval Inspection Point
- Census Metropolitan Area
- Gateway Inspection Point
- M Manual Inspection
- Census Metropolitan Area Boundary
- Canadian National Railways
- Canadian Pacific Ltd.

CITY OF GUELPH

PUSLINCH

TOWNSHIP OF FLAMBOROUGH

TOWN OF HALTON HILLS

TOWN OF MILTON

CITY OF BURLINGTON

CITY OF BRAMPTON

CITY OF MISSISSAUGA

TOWN OF OAKVILLE

TOWN OF VAUGHAN

METROPOLITAN TORONTO

DUNDAS

HAMILTON

LAKE ONTARIO

County of Wellington

Hamilton - Wentworth

Peel

York

CN Guelph Sub.

CN Halton Sub.

CP Orangeville Sub.

CP MacTier Sub.

CN Weston Sub.

CN Newmarket Sub.

CN York Sub.

CP Galt Sub.

CP North Toronto Sub.

CP Oakville Sub.

C.P. Cappa sub.

Hwy. 401

Hwy. 400

Hwy. 427

Steeles Ave

Eglinton Ave

Dundas St. W.

Queen St.

Yonge St.

Don Valley Pkwy

Gardiner Expressway

Toronto Harbour

Lambton Yard

Toronto Yard

GATEWAY INSPECTION mi. 25.0

GATEWAY INSPECTION mi. 27.7

C.M.A mi. 20.7

C.M.A mi. 25.87

C.M.A. Hamilton mi. 12.32

C.M.A. Hamilton mi. 42.6

C.M.A mi. 27.1

H.B.D. mi. 18.0

H.B.D. mi. 52.0

H.B.D. mi. 36.6

H.B.D.

mi. 17.0

mi. 0.0 Orangeville M

mi. 21.2 Galt

mi. 40.6

M mi. 7.8

mi. 12.1 Newmarket

mi. 23.6 York

mi. 7.4

mi. 5.8 Galt

mi. 0.0 N. Toronto

mi. 206.0 Belleville

M mi. 333.8

M C.N. & C.P. mi. 8.0

TOWN OF VAUGHAN
TOWN OF MARKHAM
TOWNSHIP
TOWN OF PICKERING
TOWN OF WHITBY
CITY OF OSHAWA
TOWN OF AJAX
METROPOLITAN TORONTO
CP MacTier Sub
CN Uxbridge Sub
CP Havelock Sub
CN Weston Sub
CN Newmarket Sub
CN York Sub
CP Galt Sub
CP Oakville Sub
CP North Toronto Sub.
CN Kingston Sub
Hwy 400
Hwy 427
Hwy 401
Yonge St
Steeles Ave
Eglinton Ave
Queen St
Dundas St
Gardiner Expressway
Don Valley Pkwy
Brock St.
Toronto Harbour
H.B.D.
C.M.A. mi. 39.0
C.M.A. Toronto mi. 161.33
M mi. 158.0
M mi. 183.8
C.M.A. Toronto mi. 181.48
mi. 306.0 H.B.D.
C.M.A. Toronto mp. 307.29
M mi. 7.8
mi. 17.0
mi. 12.1 Newmarket
mi. 16 Bala
mi. 18 York
mi. 50.9
mi. 23.6 York
mi. 14.0
Normal Inspection limits
mi. 178.0 Havelock
mi. 198.0 Belleville
mi. 5.0
mi. 7.4
mi. 0.0 N. Toronto
mi. 206.0 Belleville
mi. 5.8 Galt
M mi. 333.8
M C.N. & C.P. mi. 8.0
mi. 325.0
mi. 321.0
ONTARIO

TOWN OF MARKHAM

TOWN OF PICKERING

TOWN OF AJAX

TOWN OF WHITBY

TOWNSHIP OF SCUGOG

CITY OF OSHAWA

TOWN OF NEWCASTLE

LAKE SCUGOG

CN Uxbridge Sub.

CP Havelock Sub.

CP Belleville Sub.

CN Kingston Sub.

Metro Toronto Boundary

Regional Municipality of Durham

Metropolitan Toronto

C.M.A. mi. 39.0

C.M.A. Toronto mi. 161.33

M mi. 158.0

H.B.D. M mi. 163.8

C.M.A. Toronto mi. 161.48

H.B.D. mi. 306.0

C.M.A. Toronto mp. 307.29

C.M.A Oshawa mi. 170.7

C.M.A. Oshawa mi. 299.0

H.B.D. mi. 194.86

mi. 18 York

mi. 50.9

mi. 14.0

mi. 178.0 Havelock

mi. 196.0 Belleville

H.B.D.

mi. 5.0

Hwy. 401

McCowan Rd.

Markham Rd.

Brock St.

Liberty Street

Scale

mi. 326.0

mi. 321.0

mi. 299.0 C.N.

Hwy. 401

Lake Ontario

County of Victoria

The main feature of the rail network is the radial pattern of lines focussing on the city centre and the waterfront area in the vicinity of Union Station. Superimposed on this radial network is a dominantly east-west flow of traffic as is shown later.

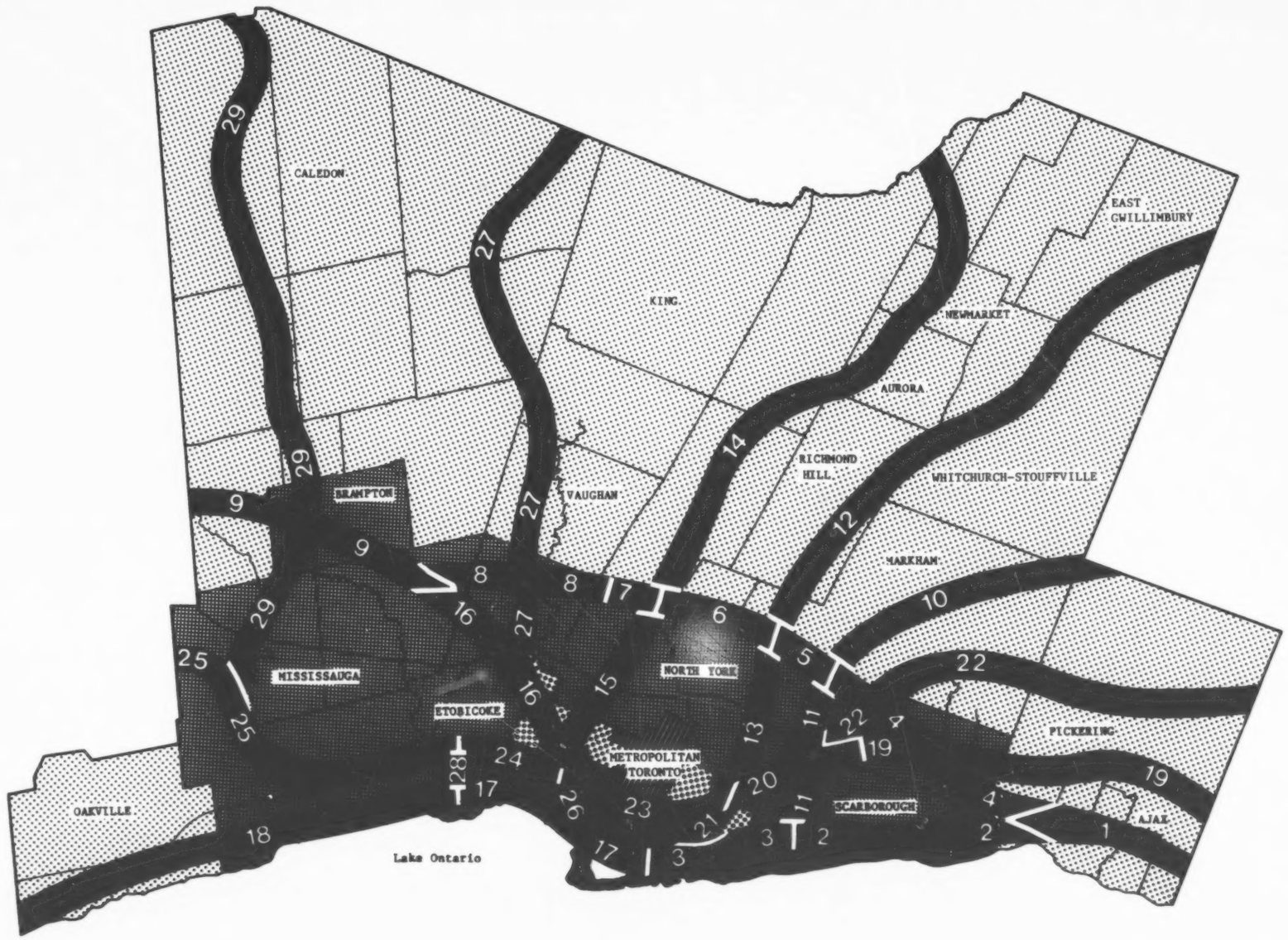
Apart from CN and CP, there are no other railway companies in the Toronto CMA, although some industrial establishments have short lengths of track within their property and move goods within their own area of operations. These ancillary services are excluded from the present study. For the purpose of visual inspection and analysis, the networks have been divided into a series of corridors, shown in Figure 4. A corridor is defined as a length of track between junctions. There are 18 corridors in the CN network and 11 corridors in the CP network. The map of corridors is superimposed on a population density map of the area.

## 3. Dangerous Commodities

The range of dangerous chemicals and other man-made substances now used in industry and trade is extensive. A current compilation lists over 2,000 items of dangerous commodities transported by rail. Of course, not all are equally dangerous. Furthermore, some commodities, not dangerous in themselves, may become so when exposed to or mixed with other substances as a result of leakages caused in accidents.

Figure No. 4

RAIL CORRIDORS AND
POPULATION DENSITY




POPULATION DENSITY
PER SQ. KILOMETRES
CENSUS METRO AREA

- Under 2500
- 2500-4999
- 5000-7499
- 7500-9999

CN Corridors 1-18
CP Corridors 19-29

SCALE 1:250,000

Miles 2 0 2 4 6

Kilometres 2 0 2 4 6 8

Source: Census of Canada, 1981

A list of the twenty dangerous commodities most frequently shipped by CP Rail in the Toronto region is listed in Table 5. Because the commodities listed in Table 5 are the most frequently transported they are also the most likely commodities to be involved in an accident. It does not follow that these necessarily pose the highest risk. That depends also on the nature of the commodity.

Because the transportation of dangerous commodities requires special regulation and because they are shipped between nations an international approach has become necessary. A classification of dangerous goods has been developed by the United Nations and is now in widespread use. The nine classes are listed in Table 6.

For the purpose of the application of the most strict operating procedures on the railways in Canada, a category of Special Dangerous Commodities has been created. These are commodities thought by the Railway Transport Committee to pose a special or more serious risk than other dangerous commodities.

Altogether there are 379 commodities classified as "special dangerous commodities". Most of these are in three classes-- explosives, gases, and poisonous substances. The distribution of special dangerous commodities by class is shown in Table 6.

TABLE 5

TWENTY MOST FREQUENTLY TRANSPORTED DANGEROUS COMMODITIES (1980) C.P. RAIL

| COMMODITIES: | TANK CARS | OTHER | TOTAL CARS |
|---|---|---|---|
| Propane | 15,817 | 491 | 16,308 |
| Gasoline | 11,882 | 32 | 11,914 |
| Sulphuric Acid | 8,551 | 65 | 8,615 |
| Anhydrous Ammonia | 7,819 | 116 | 7,935 |
| Pool Car Traffic | - | 4,503 | 4,503 |
| Butane | 4,057 | 154 | 4,212 |
| Butane Impure for Further Refining | 4,130 | 37 | 4,167 |
| Methanol (Wood Alcohol) | 4,097 | 11 | 4,108 |
| Ammonium Nitrate Fertilizer | - | 3,335 | 3,335 |
| Crude Oil Petroleum | 2,443 | 16 | 2,459 |
| Sulphur Dioxide | 1,774 | 16 | 1,790 |
| Sodium Hydroxide Liquid or Solution | 1,668 | 18 | 1,686 |
| Chlorine | 1,344 | 19 | 1,363 |
| Alcohol N.O.S. (Liquor) | 138 | 1,162 | 1,300 |
| Isobutane for Further Refining | 1,267 | 14 | 1,280 |
| Sodium Chlorate | 59 | 811 | 870 |
| Liquified Petroleum Gas | 763 | 53 | 816 |
| Aviation Fuel | 777 | 1 | 778 |
| Mixed Load TOFC | - | 577 | 577 |
| Petroleum Naptha | 389 | 15 | 404 |

The distribution by class of dangerous commodities on CN Rail is shown in Table 7. This table also illustrates the monthly variation. In aggregate the variation is small, but it may be significant for individual commodities.

The ten most frequently transported special dangerous commodities, and the ten most frequently transported other dangerous commodities are shown for C.N.R. in Table 8.

TABLE 6

U.N. Dangerous Goods Class Schedule

And Number of Special Dangerous Commodities

| | | Number of "Special" Dangerous Commodities |
|---|---|---|
| Class 1 | Explosives | 159 |
| 2 | Gases: Compressed, liquefied, dissolved under pressure or deeply refrigerated | 107 |
| 3 | Flammable and Combustible liquids | 4 |
| 4 | Flammable Solids, substances liable to combustion, substances that on contact with water emit flammable gases | |
| 5 | Oxidizing substances; organic peroxides | 14<br>3 |
| 6 | Poisonous (toxic) and Infectious substances | 87 |
| 7 | Radioactive materials | 5 |
| 8 | Corrosives | 10 |
| 9 | Miscellaneous Dangerous Goods | 0 |
| | | 389 |

Source: Transport of Dangerous Goods: A compilation of the Recommendations prepared by the United Nations Committee of Experts on the Transport of Dangerous Goods. 1981 Edition. Printed by: International Regulations Publishing and Distributing Organization. Chicago, Illinois.

TABLE 7

CARLOADS OF DANGEROUS COMMODITIES CN RAIL
BY COMMODITY CLASS JANUARY 1982 TO JUNE 1982

| CLASS | JAN. | FEB. | MARCH | APRIL | MAY | JUNE | 6 MONTH TOTAL | MONTHLY AVERAGE |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 5 | 9 | 27 | 9 | 7 | 58 | 9.66 |
| 2 | 892 | 1000 | 944 | 824 | 861 | 922 | 5443 | 907.16 |
| 3 | 414 | 414 | 518 | 405 | 462 | 525 | 2738 | 456.33 |
| 4 | 64 | 36 | 56 | 37 | 43 | 48 | 284 | 47.33 |
| 5 | 189 | 125 | 116 | 130 | 151 | 94 | 805 | 134.16 |
| 6 | 126 | 54 | 82 | 45 | 37 | 64 | 408 | 68.00 |
| 7 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | .50 |
| 8 | 220 | 325 | 298 | 345 | 398 | 299 | 1885 | 314.16 |
| 9 | 548 | 567 | 610 | 645 | 620 | 679 | 3669 | 611.50 |
| TOTAL CARS | 2457 | 2526 | 2633 | 2458 | 2581 | 2638 | 15,293 | 2548.83 |
| TOTAL TRAINS | 482 | 486 | 551 | 489 | 481 | 496 | 2,985 | 497.5 |

Source: CN Rail Report. Carloads and Trains
Dangerous Commodities
January to June 1982

TABLE 8 THE TEN MOST FREQUENTLY TRANSPORTED SPECIAL DANGEROUS COMMODITIES AND OTHER DANGEROUS COMMODITIES, CN RAIL, TORONTO C.M.A.

| PRODUCT | CAR VOLUME 6 MONTHS JAN-JUNE 1982 |
|---|---|
| Propane - Propylene | 2,183 |
| Anhydrous Ammonia | 1,265 |
| Butane - LPG | 986 |
| LPG | 506 |
| Chlorine | 163 |
| Calcium Cyanide | 80 |
| Phosphorus (W-or-Y) | 73 |
| Methylacetylene - Propadiene Stabilized | 53 |
| Sulfur Dioxide | 65 |
| Motor Fuel Anti-Knock Compound | 50 |
| OTHER DANGEROUS COMMODITIES: | |
| Gasoline | 1,074 |
| Sodium Hydroxide | 769 |
| Ammonia Nitrate Fertilizer | 441 |
| Sulfuric Acid | 469 |
| Petroleum Oil Products | 285 |
| Benzene | 111 |
| Flammable Liquids N.O.S. | 196 |
| Toluene | 113 |
| Acids, Chemicals and Other Articles | 149 |
| Batteries, Electric Storage, Wet | 158 |

Source: CN Rail Report. Carloads and Trains Dangerous Commodities January to June 1982

## 4. Dangerous commodity flows

In order to describe dangerous commodity flows over a given network of rail lines we need data on the quantity of each commodity and the route which it follows over a given period of time.

The volume of potential statistics that could be gathered to describe this system is enormous. Railways have often been described as organizations established for the purpose of generating statistics. It is necessary, therefore, to be selective. More detail can be provided should that seem desirable.

In order to model commodity flow, the origin, destination and length of each trip would be needed for each commodity. At this stage, we have simply requested from the railways dangerous commodity flow by carloads. Note that the number of carloads indicates nothing about the number of trains. Some trains carry no goods classified as dangerous. Others carry many carloads of several different kinds of dangerous goods, and special dangerous commodities.

The number of carloads in this data means carload-trips, irrespective of the origin and destination of the car or of the length of trip. This is important from the viewpoint of the estimation of probabilities.

Figure 5

SCHEMATIC DIAGRAM OF ROUTES
WITH DANGEROUS COMMODITY CAR COUNTS

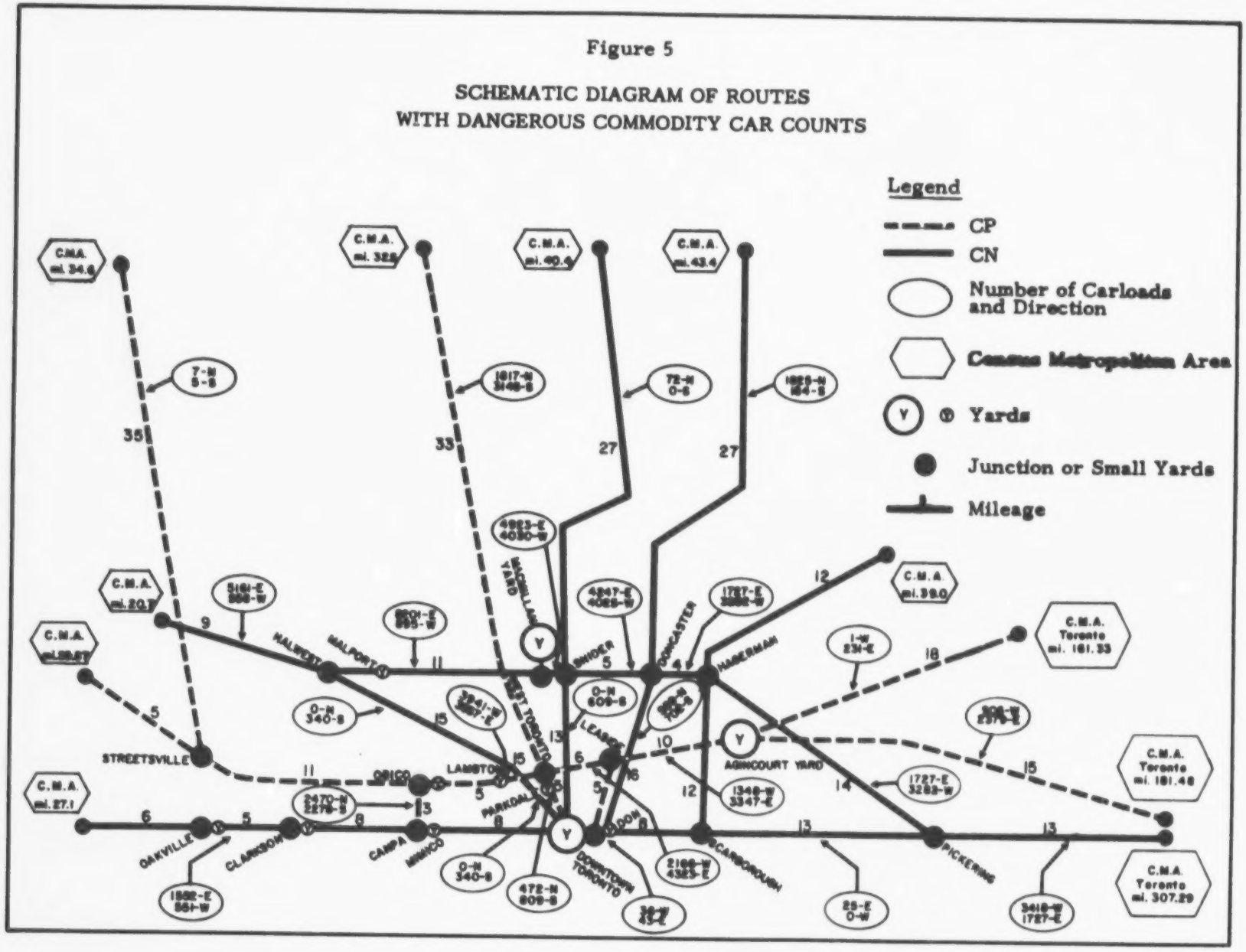


Figure 6

FLOW CHART
OF DANGEROUS COMMODITY LOADS
CP RAIL

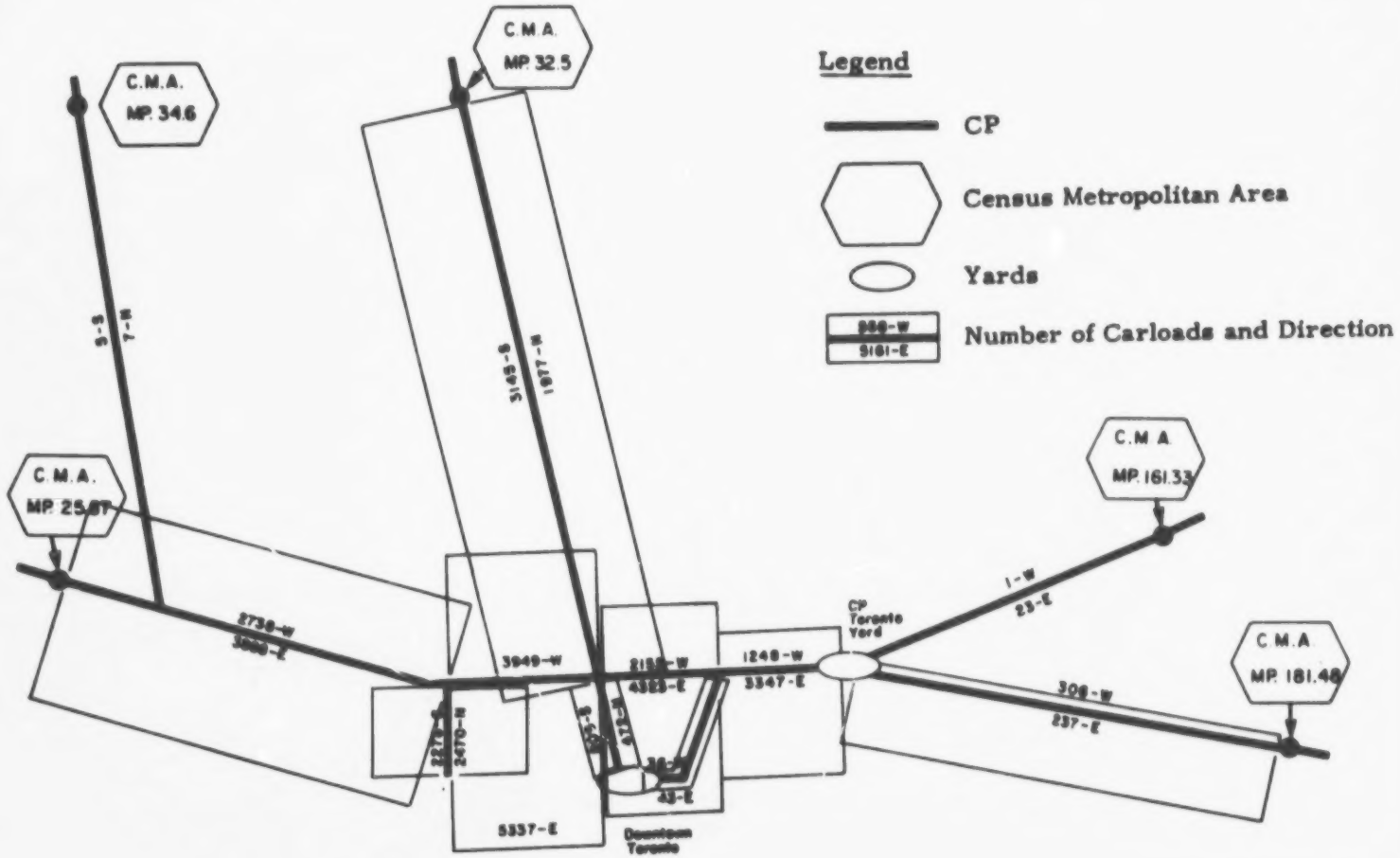
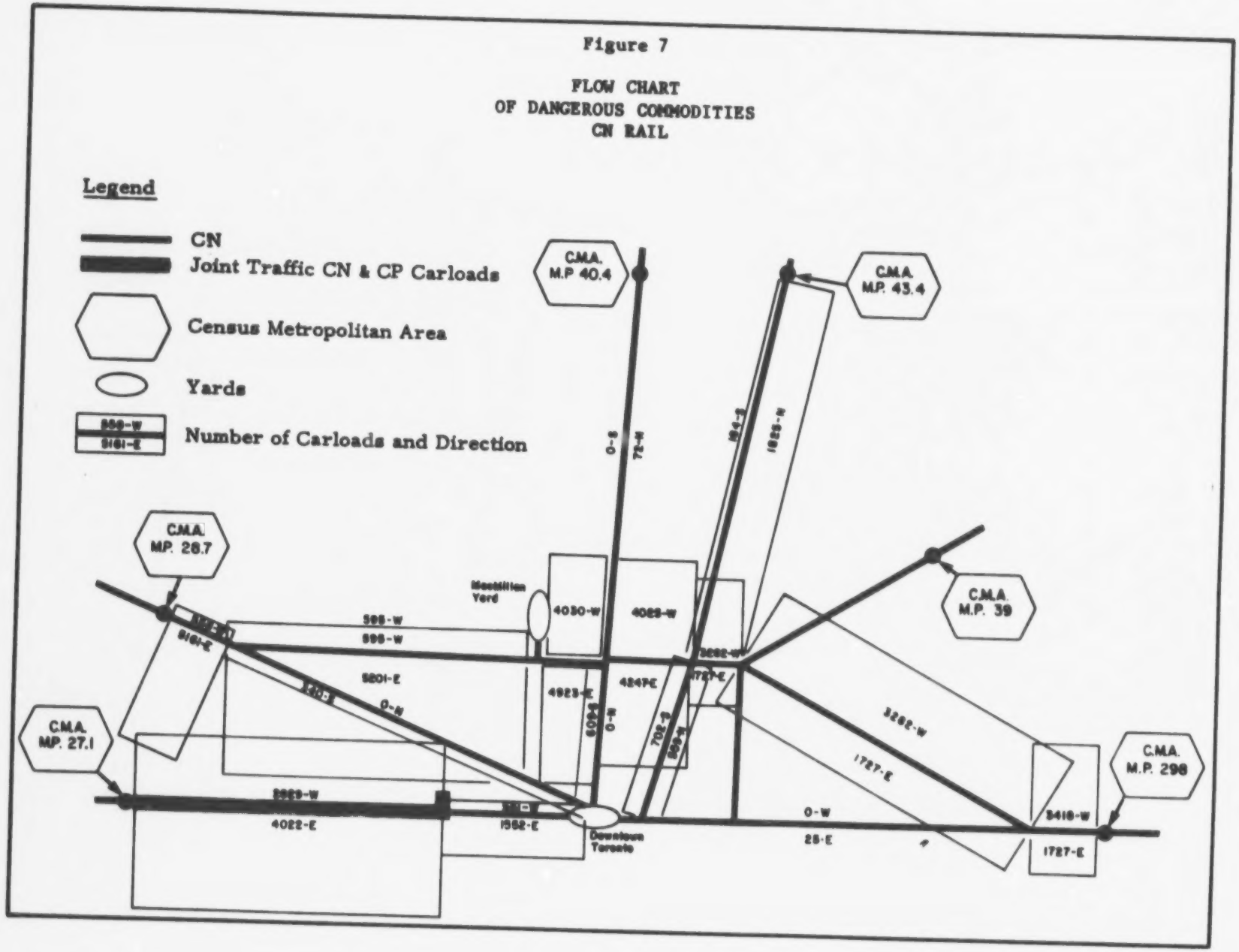


Figure 7

FLOW CHART
OF DANGEROUS COMMODITIES
CN RAIL



The data used in this study are for a six month period from January to June 1982. This is thought to be a fair reflection of the current volume of carloads. The general trend has been upwards although the 1982 volume is down somewhat (especially the latter half of the year) due to the slackening in the economy.

Carloads of all dangerous commodities on CN rail for this six month period are shown in Table 7. A total of 15, 293 carload-trips were made, and 2985 trains were involved. Comparable figures for CP Rail are 9334 carloads of dangerous commodities, and 1664 trains.

The pattern of flow of these dangerous commodities over the rail network is shown in Figure 5. For each corridor, the number of dangerous commodity cars is shown in an oval-shaped label. Two figures appear in each label indicating the number of cars moved east and west or north and south according to the main orientation of the corridor.

In order to present a more visually interpretable picture of dangerous commodity flows by carloads a flow chart has been drawn for each network in Figures 6 and 7. In Figure 6, it can be seen that the major CP flow is east and west, along the Galt Subdivision, and east and west on the Belleville Subdivision. There is also a major flow north and south (MacTier Subdivision). The CN flow (Figure 7) is similarly concentrated in the east-west corridor, along the Halton Subdivision, passing north of Metropolitan Toronto (York Subdivision) and east and west on the Kingston Subdivision.

Other major flows on the CN network include an east-west flow along the lakeshore on the Oakville Subdivision and north-south flow on the Bala Subdivision.

These flows on Figures 6 and 7 have been further simplified on Figure 8 into major and minor flows. A minor flow is defined as less than 2,000 carloads of dangerous commodities per month.

5. Accident locations

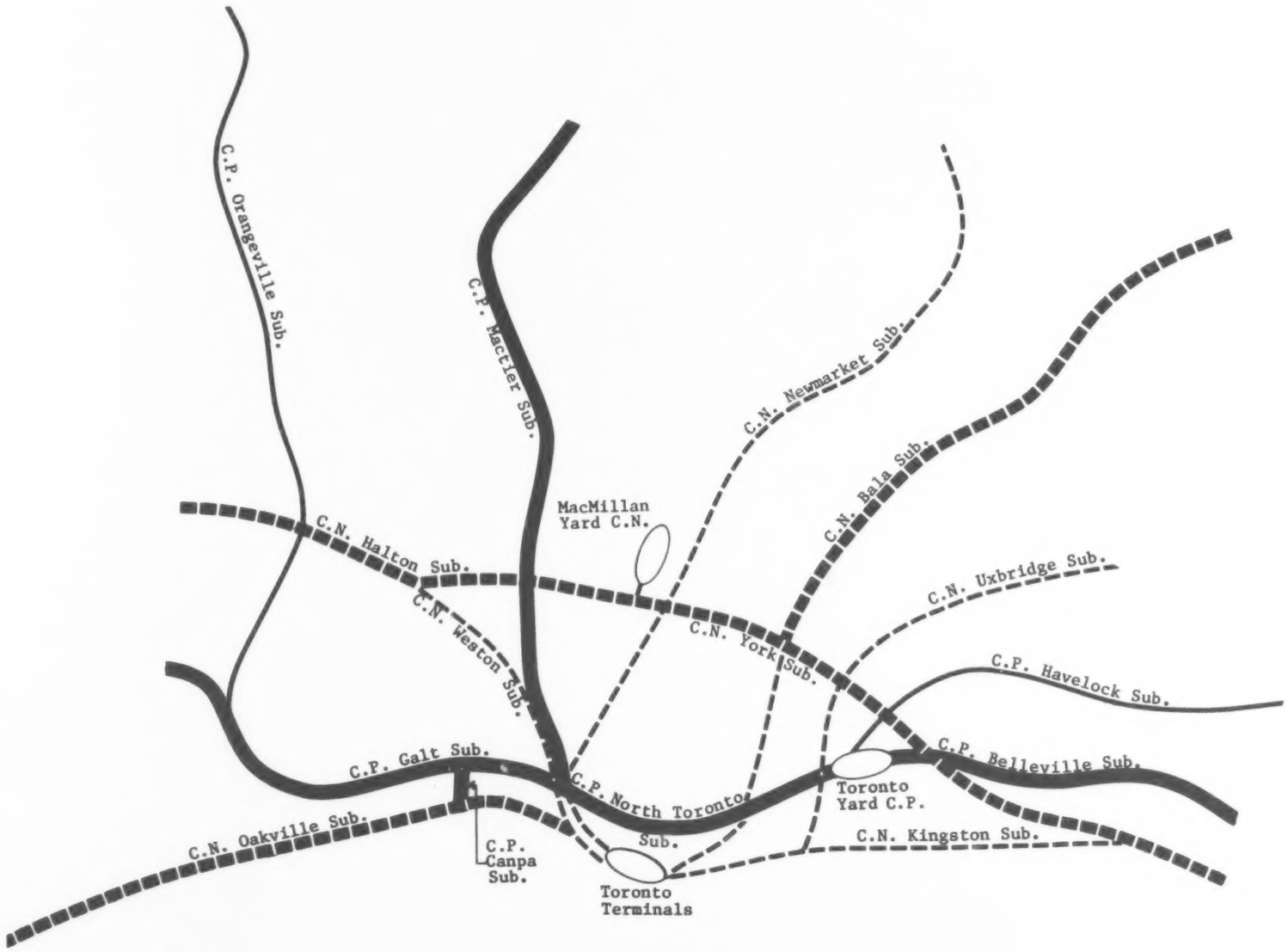
For the purposes of risk analysis it is sometimes assumed that the probability of accidents is equally distributed over the rail network and that the location of accidents is an essentially random phenomenon. Clearly, this assumption is not valid. Curve and level crossings are potential danger points.

The quality of the road bed or track is also a factor in accidents. Continuous welded rail, for example, is safer than jointed rail. The former are slowly replacing the latter in the Toronto rail network but the change-over is not yet complete.

Whereas level crossings and track quality might be taken to indicate areas of higher risk, the adoption of restricted speeds on specific lengths of track is likely to reduce the probability of accidents, or their severity, should they occur.

Figure 8

MAJOR AND MINOR FLOWS
OF DANGEROUS COMMODITIES
TORONTO CENSUS METROPOLITAN AREA
JAN. - JUNE 1982 DATA




January to June 1982
Flow Pattern of Dangerous Commodities

CN } Major Flow >2000 Carloads
CP }

CN } Minor Flow <2000 Carloads
CP }

Appendix Table A shows crossings and track data for the 18 corridors on the CN network. The least protection is provided by reflector crossing signs. Only nine of these remain. Most crossings have been converted into grade separations, but a substantial number of level crossings remain. There are 10 in the 13 mile length of Corridor No. 2 in the Kingston Subdivision.

Similar crossing and track data is given for the CPR network by corridors in Appendix Table B. The overall track condition is generally described as "good" but in both CN and CP networks, some corridors are described as "adequate".

No method has yet been developed for incorporating such data into a formal risk assessment. This could be done if it seems desirable to pinpoint areas of risk more precisely.

Data on train speeds and inspection procedures by corridor is given for CNR in Appendix Table C. Detailed examination of this table, and similarly Appendix Table D for CPR provides precise information on the operations in each corridor. Assessments of risk at specific points or by corridor should ideally take these speeds and operating rules into account. No formal method for doing this has yet been developed.

## 6. Trans-shipment Points

There are more than 60 trans-shipment points in the Toronto CMA as shown in Figure 9. Some of the circles (59 in all) represent several small trans-shipment points.

In terms of carloads of dangerous goods, there are 6 points which stand out as significantly larger than others. Four of these are along the Oakville Subdivision of CNR. These are at the oil refineries belonging to BP, Shell, Gulf and Texaco. The bulk of the cargoes trans-shipped are flammable liquids, with flammable gases the second largest commodity in terms of tank cars.

Another large trans-shipment point, or more correctly, group of points, is in the vicinity of the Toronto Harbour. Here again flammable liquids are the major commodity.

Another larger trans-shipment centre is located near to Finch Avenue in Downsview where Petrocan and Imperial Oil have major installations. Again, flammable liquids are the class of commodity handled.

In addition to these major volumes, there are concentrations of trans-shipment points at the city end of the McTier Subdivision (CPR) and along the Newmarket Subdivision (CNR) near the MacMillan Yard.

TOWN OF CALEDON

TOWNSHIP OF KI

CITY OF GUELPH

TOWN OF HALTON HILLS

CITY OF BRAMPTON

TOWN OF V

Peel

York

HIGHWAY 10

HIGHWAY 25

HIGHWAY 400

C.N.

C.P.

Halton

METROPOLITAN

5

15

2

138

63

7

4

6

17

2

5

25

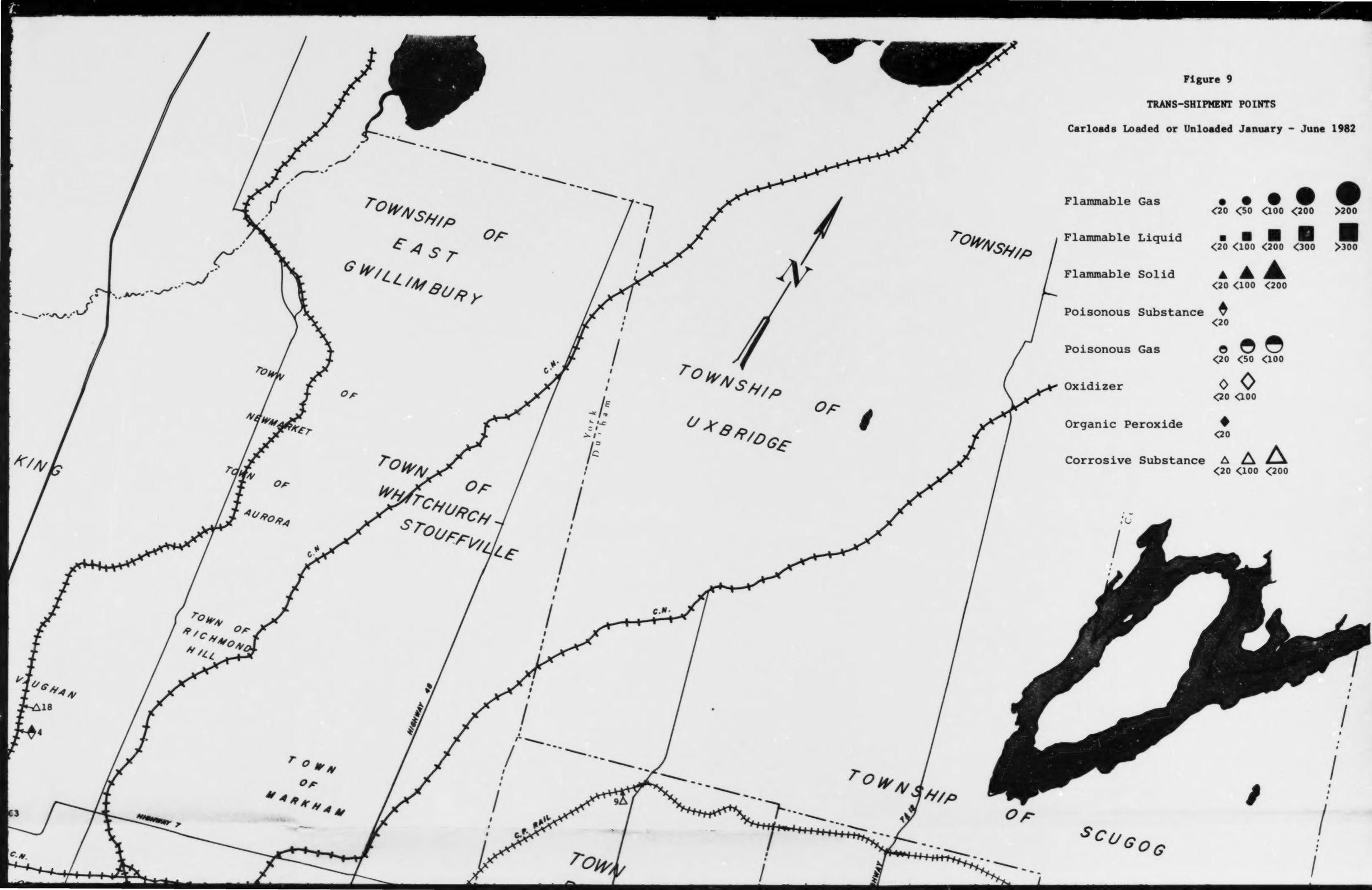
12

384

**Figure 9**

**TRANS-SHIPMENT POINTS**

**Carloads Loaded or Unloaded January - June 1982**



GUELPH

HIGHWAY 25

TOWN OF HALTON HILLS

CITY OF BRAMPTON

Peel Halton

C.N.

C.P.

HIGHWAY 400

METROPOLITAN

TOWN OF MILTON

CITY OF MISSISSAUGA

Eglinton Ave

TOWNSHIP OF FLAMBOROUGH

CITY OF BURLINGTON

TOWN OF OAKVILLE

HIGHWAY 6

QUEEN ST.

TORONTO HARBOUR

DUNDAS

HAMILTON

VAUGHAN
△18
4
63
HIGHWAY 48
TOWN OF MARKHAM
HIGHWAY 7
C.N.
TORONTO
C.N.
C.P. RAIL
9△
TOWN OF PICKERING
HIGHWAY 7
TOWN OF WHITBY
HIGHWAY 7&12
TOWNSHIP OF SCUGOG
C.P. RAIL
CITY OF OSHAWA
48
2
33
16
C.P. RAIL
30
12
MARKHAM RD.
C.P. RAIL
TOWN OF AJAX
C.N.
6
16
C.N.
TOWN OF NEWCASTLE
7
△6
18
C.N.
101
5
5
101
KINGSTON RD.
83
△20
△18
3
HIGHWAY 2
C.P. RAIL
C.N.
C.P. RAIL
Scale
1000 0 1000 2000 3000 4000 METRES

There is a notable lack of trans-shipment points along the corridors of highest relative risk from the movement of dangerous commodities along the North Toronto Subdivision at the Galt Subdivision (Corridors 23 and 24) of the CPR. The concentration of points in Leaside where a variety of chemical products are trans-shipped is served by the CNR from the Bala Subdivision. The derivation of the index of relative risk is detailed below in Section IV.

7. Actions taken to reduce risk

Regulations are issued in the form of Orders, General Orders and those addressed to specific issues and companies.

The Canadian Transport Commission issues General Orders to all forms of Transportation falling within its jurisdiction.

The Railway Transport Committee is one of a number of modal Committees within the Canadian Transport Commission and is empowered to issue orders on specific issues and these are directed to individual Railway Companies.

The Railway Transport Committee is constantly striving to improve safety on all railways under its jurisdiction, however, this must be accomplished within the bounds of the policy of directives set out in Section 3 of the National Transportation Act.

Since 1909, orders have been issued regarding the transportation of hazardous commodities by rail, one major order being C.T.C. General Order 1974-1 Rail which provided for the Regulations for Transportation of Dangerous Commodities by Rail, commonly called the Red Book. These regulations set out the classifications, definitions of and the preparation for shipment of Explosives, Flammable Liquids, Flammable Solids, Corrosives, Poisonous Commodities, Radioactive Materials, Labelling, Placarding and the necessary documentation, such as Way Bills and Emergency Response Forms must be completed before a Railway Company accepts a car.

These Regulations also outline the Specifications for all classes of tank cars used in transporting Dangerous Commodities.

C.T.C. and R.T.C. Orders are constantly being issued on safety issues on all matters concerning rail operation.

A summary of some of the changes, insofar as hazardous commodities are concerned, are as follows:

> As a result of several years of studies to effectively reduce the risk of spills and explosions, as a result of a derailment the Canadian Transport Commission issued CTC General Order 1979-1 Rail dated January 22, 1979, requiring that all class 112/114 tank cars be equipped with tank head puncture resistance system

(i.e. head shields) and double-shelf couplers. Also, all such cars used in the transportation of flammable compressed gases be equipped with a thermal protection system.

Effective Date for Tank Head Resistance System - June 30, 1981
Effective Date for Double Shelf Couplers - March 31, 1979
Effective Date for Thermal Protection System - June 30, 1981

Head Shields provide extra protection and reduce the possibility of a puncture occurring during a derailment by a coupler of an adjoining car or broken rail.

Double-shelf couplers act to prevent or deter unintentional uncoupling of cars during train operations and accidents and the resultant punctures in the heads of adjoining cars.

The thermal protection system provides protection from direct impingement of flame on the shell of the tank car extending time limits in which necessary action can be taken.

Data compiled since these modifications have been introduced shows a significant decrease in these types of accidents. According to a report by the Railroad Tank Car Safety Research and Test Project, in the 14 years prior to the retrofit program; head punctures averaged 8.9 per year, this has dropped to .44 per year.

Fire induced tank ruptures for the same period averaged 6.9 and have now dropped to .44 per year. These figures are based on a 27 month follow-up study period. Ref. Report RA-02-3-44 (AAR R-482)

Order No. R-30031 dated November 27, 1979, required that tank car shipments of flammable compressed gases must be separated from tank shipments of chlorine, anhydrous ammonia or sulphur dioxide by at least 5 non-placard rail cars.

On May 28, 1982, Order No. 32284 was issued directing Canadian Pacific Ltd. to install, in addition to the hot box and dragging equipment detectors installed on its line prior to January 1, 1981, 154 additional detectors before December 31, 1983.

The Show Cause Hearing Decision on Railway Safety dated September 30, 1981, following the hearing of evidence in support of and against the recommendations contained in the Report of the Mississauga Railway Accident Inquiry made a number of decisions.

One was to extend the protection ordered by C.T.C. General Order 1979-1 Rail to include all new class 105 tank cars. Class 105 tank cars were not dealt with in Mississauga Railway Accident Inquiry.

A summary of the 18 decisions arrived at on September 30, 1981, to improve safety in transporting hazardous goods, are as follows:

ROLLER BEARINGS:

Canadian railways are to convert to roller bearings sufficient cars to ensure that 75 percent of their owned and leased revenue car fleet are roller bearing equipped by December 31, 1987 (year-end progress reports are to be submitted by each railway to the RTC). As well, all cars newly acquired or leased by Canadian railways shall be roller bearing equipped.

TANK CAR MODIFICATIONS:

Double Shelf Couplers

No specification 105 tank cars carrying any regulated commodity will be accepted for transport after June 30, 1982, unless equipped with double shelf couplers.

No specification 103, 111 or other CTC specification tank cars carrying any regulated commodity will be accepted for transport after February 28, 1985, unless equipped with double shelf couplers.

No tank car built after the date of issuance of this decision will be accepted for transport unless equipped with double shelf couplers.

HEAD SHIELDS:

Only full head shields are to be used henceforth on new cars and for future retrofitting.

All new 105 tank cars constructed after December 31, 1981, with the exception of those constructed to a service pressure of 500 or more PSI, shall be equipped with a tank head puncture resistance system equivalent to that now required for specification 112 and 113 tank cars or they will not be accepted for transport.

THERMAL PROTECTION:

No specification 112 and 114 tank cars carrying any dangerous commodity will be accepted for transport after December 31, 1982, unless equipped with thermal protection.

All new 105 cars constructed after December 31, 1981, shall be equipped with thermal protection or insulation equivalent to the present requirements for 112 and 114 tank cars or they will not be accepted for transport.

BOTTOM FITTING PROTECTION:

All new cars equipped with bottom outlets or other bottom discontinuities built after December 31, 1981, shall have such outlets protected as set out in the AAR Specifications for Tank Cars or recessed below the surface of the tank shell or they will not be accepted for transport.

BOTTOM FITTING PROTECTION CONT'D:

The Dangerous Commodity Technical Review Committee shall prepare and submit to the Railway Transport Committee,

(i) by February 1, 1982, a retrofit schedule for the protection of bottom discontinuities on all tank cars carrying special dangerous commodities.

(ii) by June 1, 1982, a retrofit schedule for the protection of bottom discontinuities on all tank cars carrying other dangerous commodities.

HOT BOX DETECTORS:

Trains carrying any special dangerous commodity shall undergo a "gateway" inspection, at minimum consisting of a hot box and dragging equipment detector or a mechanical inspection by railway employees before entering a populated area. A similar further inspection at no more than 20 mile intervals, relative to the location of the gateway inspection points, within the populated area will be required unless the special dangerous commodity train operates below 15 MPH.

The gateway inspection is to take place no closer than 3 miles and no more than 20 miles from the boundary of a populated area.

For the purpose of this requirement a populated area is defined as a densely populated area and priority is granted those areas in which evacuation in the event of an emergency would be very difficult.

HOT BOX DETECTORS CONT'D:

Due to practical difficulties in implementing the requirement it will be phased in starting with the larger cities. It will be effective:

(a) immediately upon RTC approval of plans to be submitted by each railway within sixty (60) days hereof in census metropolitan areas with a population of over 100,000 ,

(b) October 1, 1984, for populated areas with a population of 50,000 to 100,000, but not within a census metropolitan area and,

(c) October 1, 1987, for populated areas with a population of 10,000 to 50,000, but not within a census metropolitan area.

Railways shall immediately commence reporting to the Railway Transport Committee all hot box occurrences, whether or not they result in a burn-off or a derailment. Such reports are to include the type of bearing and car involved, the date and location of the occurrence, the distance from the last hot box detector and/or inspection, and whether any abnormal indication registered on the previous hot box detector.

It is recommended that the Technical Research Committee of Strategic Planning, Transport Canada investigate the possibility of conducting tests on the time taken for a roller bearing to go to failure under various conditions.

Railway companies will be expected to review their system of priorities for hot box detector installation in areas not identified in item 11 to

ensure that the highest priority is dictated by the level of dangerous commodity traffic and in particular the level of special dangerous commodity traffic.

TRAIN LENGTH:

No restrictions will be imposed on train length.

TRAIN SPEED:

In census metropolitan areas with a population of 100,000 or more, trains carrying special dangerous commodities shall travel at no more than 35 MPH and in areas of population from 50,000 to 100,000 where provisions for protection as defined in item 11 have not been implemented, trains carrying special dangerous commodities shall travel at no more than 35 MPH. In areas of population from 10,000 to 50,000 not protected as defined in item 11 trains carrying special dangerous commodities shall travel at no more than 35 MPH after October 1, 1987.

CAR INSPECTION:

Regulations will be drafted requiring a prescribed complete mechanical inspection by qualified personnel of all rail cars in a train, whether carrying dangerous commodities or not, at intervals to be specified by the Commission, and at interchange points before acceptance for forwarding from another railway.

Further regulations will be drafted such that cars loaded with dangerous commodities initially received by the railway from a shipper or manufacturer

must receive a prescribed mechanical inspection to be performed by qualified railway personnel not farther than 25 miles from the shipper or manufacturer point of origin.

In the interim, Section 74.596 of the Regulations for the Transportation of Dangerous Commodities by Rail (which requires inspection of tank cars carrying dangerous commodities before acceptance by a carrier) will be enlarged to include all cars carrying dangerous commodities (and not just tank cars).

Those orders provided for within the decision have been issued.

8. Effects of Actions Taken

The effectiveness of the head shield, shelf coupler, and thermal insulation has been indicated by the significant reduction in this kind of damage as outlined in Report #RA 02-03-44 (AAR R-482) dated May 15, 1981, of the R.P.I. - AAR Railroad Tank Car Safety Research and Test Project. The conclusions arrived at in this report are as follows:

Under HM-144, the entire fleet of 112(114) cars has now had about 2-3/4 years experience with shelf couplers and 1-3/4 years with head shields and thermal shields. Compared to 14 years previous experience without these items, accident data show:

1. the frequency of head punctures had been reduced to about one-seventh the previous rate;

2. shell punctures have been reduced, but there are not a sufficient number of cases to quantify the degree of improvement;

3. the frequency of ruptures due to fire has been reduced to about one-third the previous rate;

4. the frequency of lading loss cases due to head punctures, shell punctures and fire induced ruptures combined has been reduced to about one-third the previous rate;

5. when normalizing on the basis of car population, the frequency of lading loss cases under (4) above has been reduced to about one-fourth the previous rate.

The Gateway Inspection Program effective since March 1, 1982, has increased train inspection and reduced train speeds in all Census Metropolitan Areas. (C.M.A.)

By requiring a Gateway Inspection be performed before entering a C.M.A. and further interval inspections be made at twenty mile intervals within the C.M.A.

A speed restriction of 35 MPH on trains carrying Special Dangerous Commodities has been in effect since September 30, 1981.

For example, a westbound train with one or more fully loaded cars of Special Dangerous Commodities entering the C.M.A. of Toronto on C.P. Rail Belleville Subdivision receives a Gateway Inspection at Mileage 164.56 (Newcastle), an interval inspection at Mileage 183.8 (near Harwood Road, Ajax) and if running through receives another interval inspection at Mileage 200.6 (near Kennedy Road). In addition to these inspections the train speed is restricted to 35 MPH.

Further interval inspections are made at Mileage 7.4 of the C.P. Galt Subdivision (near Royal York Road) with a final inspection at Mileage 25.0.

An eastbound train would receive the same inspections with a Gateway Inspection at Mileage 42. of the Galt Subdivision.

The present location of Hot Box and Dragging Equipment Detectors ensures that prior to moving into Corridors 23 and 24 (North Toronto and Galt Subdivisions), trains have been inspected at least twice and in some cases three times by Hot Box and Dragging Equipment Detectors.

Trains originating at Toronto, containing Special Dangerous Commodities, are completely inspected by qualified mechanical personnel and are also restricted to 35 MPH.

A further reduction in speed to 15 MPH as proposed by the City of Toronto would, as stated in the Show Cause Hearing Decision Pg. 46-49, result in higher train forces resulting in knuckle and draw bar failure which can result in derailment, as well as increasing noise pollution.

It is the conclusion of the Ontario Regional Office that the increased frequency of train inspections and the restriction of train speeds to 35 MPH is sufficient action to minimize the possibility of a derailment occurring. (Accident data).

Constant monitoring of the train speeds by radar and inspection points within the Census Metropolitan Area of Toronto by Ontario Regional Officers, has indicated train crews are complying with the requirements of the Gateway Inspection Program.

The suggestion of colour coding of cars carrying Special Dangerous Commodities has been reviewed and it is not considered feasible as the number of different products far out-number the range of colours available, the restrictive nature insofar as the utilization of the equipment and the extremely high cost of repainting the car each time it is used for a different product.

An amendment to Section 72 of the Regulations for the Transportation of Dangerous Commodities by Rail dated January 8, 1981, requires that tank cars carrying such products as Anhydrous Ammonia, Liquified Petroleum Gas, Sulphur Dioxide, Vinyl Chloride are to be marked as follows:

> The letters in the name of the commodity shall be no less than 101.6 mm in height with no less than a 15.9 mm stroke.
>
> The separation between each letter shall be no less than 19.9 mm.
>
> Every name prescribed in subsection 72.6(a) shall be marked on each side of the tank car, and except for CTC 106 and 110 multi-unit tank car tanks, readily visible when viewed from each side of the tank car.
>
> A tank car marked with the name of a commodity shall not be used to transport any commodity other than the one whose name is marked on the tank.

Studies conducted by Arthur D. Little Inc. for the Federal Railroad Administration, Office of Rail Safety Research, in regard to, locating loaded tank cars to the rear of the train, are inconclusive. The data available does not take into account the effects of loaded/empty car distribution throughout a train.

## IV CONSEQUENCE FACTORS

The character of the rail networks, the volumes of flow of dangerous commodities, as well as track conditions, train speeds, and inspection procedures are all factors that play a powerful role in determining when and where accidents will occur.

The next component of risk assessment deals with the question "What if an accident were to happen at....?"

Clearly the precise location of the accident can make a large difference to the consequences. In the case of the Mississauga derailment for example, it has been estimated that if the accident had occurred twenty minutes later, the train would have been somewhere in the centre of Toronto, in the vicinity of the Yonge Street bridge.

There are many factors which affect the consequences of an accident. Prominent among them is the nature of the accident itself, particularly the magnitude of any fires or explosions and the character of any dangerous goods released into the environment.

A variety of social factors can also be important. These include the possible presence of schools, hospitals or homes for the aged and infirm. Where such facilities are present, housing people less able to take care of themselves, more severe impacts are possible.

A thorough-going risk analysis might be expected to incorporate estimates of the power of these various factors in a model of impact or vulnerability. The development of such a model is beyond the scope of this report. However, it is worth mentioning briefly some of the ways in which these factors can operate.

Population density is a measure of the number of people likely to be at risk. Accidents occurring in open country or in farmland are likely to have less serious consequences than those in high density residential areas.

Studies of response to emergencies have shown that an immediate and dominant behavioural response is to ty to locate other members of the family group. This can lead to much confusion and can seriously impede the evacuate process, and the access of emergency service to the site. Accidents are expected to have less impact, therefore, when they occur at times when family groups are more likely to be together than when they are widely scattered at work and school. In this regard, the timing of the Mississauga accident occurring just before midnight on a Saturday evening facilitated the evacuation process.

Some poisonous gases (chlorine for example) are heavier than air and when released are likely to spread as a low "cloud" close to the ground. The direction and speed of the flow can be affected therefore by the slope of the ground, (the gas will collect in low-lying areas) by the speed of the wind,

and the amount of atmospheric turbulence, those living higher up in apartment buildings could be above lethal concentration of lethal gases while those at ground level could be more vulnerable.

Given the variety of dangerous commodities being transported by rail, and the variations in land use, social and economic activity and environmental conditions along the track, the number of possible combinations of factors is virtually infinite. Each accident is indeed unique. If general conclusions are to be drawn about the risk of transporting dangerous goods, it is nevertheless essential to seek for common features.

1. Land Use and Population Density

In order to gain some knowledge of the variability in the level of possible consequences of accidents within the Toronto CMA, we have examined land use and population density.

Land use has been examined on a large scale air photo mosaic which can be seen in the R.T.C. Regional Office. Inclusion of the mosaic in this report is not practicable. The air photo mosaic is valuable for identification purposes and can be used in further detailed risk analyses.

The rail network has been superimposed upon a population density map of the CMA (Figure 10). This gives a visual impression of those areas where population concentrations are highest in relation to the network.

TORONTO

Sec 4 of 4

Sec 3 of 4

Lake Ontario

CENSUS OF CANADA, 1901

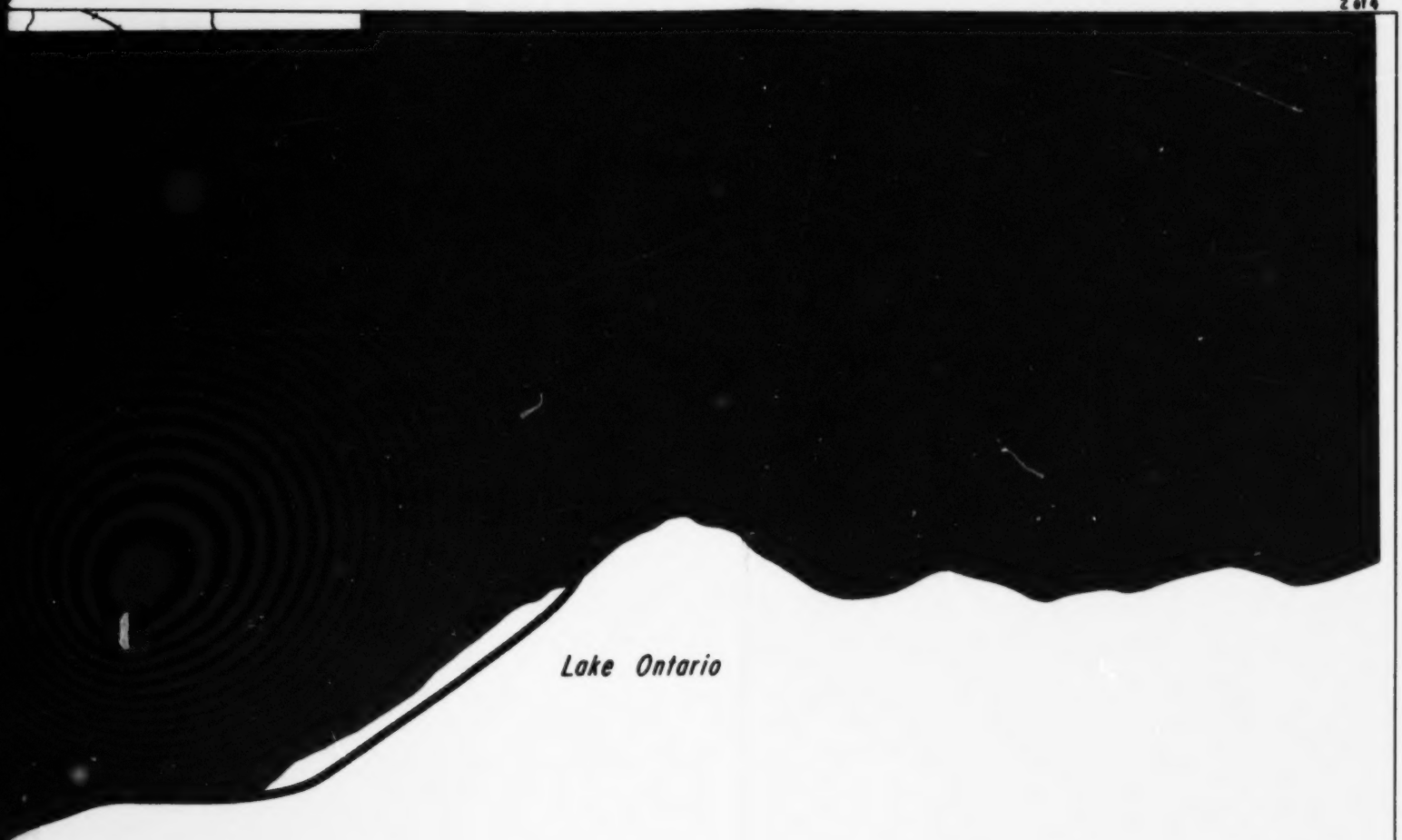



Figure 10

THE RAIL NETWORK AND POPULATION DENSITY

Railways
Inner Corridor
Outer Corridor

Population Density

< 3000
3000 - 6000
6000 - 9000
9000 - 12000
> 12000

NORD
NORTH

SCALE 1:75,000 ÉCHELLE

Miles 1 0 1 Miles
Kilometres 1 0 1 Kilomètres

2. Inner and Outer Zones

To be more precise, population density along the rail corridors has been measured. For this purpose, two risk zones have been defined along the railway lines. The inner risk zone is a strip of land 250 meters wide on each side of the tracks. This distance is assumed to be a reasonable limit beyond which the impact of short-range events (explosions and fires) are less likely to have major impact. The total width of the inner zone is thus .5 km. Similarly, an outer risk zone is defined as one kilometer on either side of the track, making a 2 km. total width. The distance of 1 km. is assumed to be a reasonable limit beyond which the major impacts of "mobile" agents such as drifting clouds or poisonous gas or other dangerous chemicals are less likely to extend.

Clearly, it is always possible that impacts will extend well beyond these ranges. The shock waves from the explosions of this Mississauga derailment have reported to have caused "window breakage and some structural damage to buildings with a 600 metre radius" (Burton, Victor and Whyte, 1981, p. 216), and the farthest points evacuated were 10 km. from the accident site.

The two zones were drawn on detailed population distribution maps of Toronto CMA by census tracts and population densities calculated. The density per square kilometer is shown in Tables 9 (CNR) and 10 (CPR), together with the number of trains carrying dangerous commodities in the six month period (January - June 1982) and the number of carload trips in the same period.

Note that the population density of the outer zone includes the population within the inner zone. Where railway lines approach within 1 kilometer of each other or intersect, the intervening population is counted twice; once for each railway corridor. The population numbers do not correspond to the total number of people at risk, but describe the relative exposure along each corridor.

3. The Relative Risk Index

The population density for each corridor and each zone has been multiplied by the mean monthly carloads of dangerous commodities passing along the corridor. This gives a number which may be referred to as a relative risk index. It is a measure based on only two variables of population density and carloads of dangerous goods. Nevertheless, it provides some information about relative risk. It assumes that the probability of an accidental release of a dangerous commodity is roughly proportional to the number of carloads of dangerous commodities passing along a particular corridor (the probability factor), and that the consequences are roughly proportional to the population density along the tracks in the inner and outer zones.

The distribution of corridors according to the value of the relative risk index is shown in Tables 11 and 12. The reference made to dangerous commodities means Special Dangerous Commodities as prescribed by the Canadian Transport Commission.

TABLE 9/1

DANGEROUS COMMODITIES AND POPULATION DENSITY -- CNR

| Corridor # | Volume of Dangerous Commodities Handled In Cars 6 Month Period | Number of Trains In 6 Month Period | Population Density Per Square Km. | Relative Risk Index |
|---|---|---|---|---|
| #1 Kingston Sub. Mile 311.4 - 307.29 (4.11MI) 6.6 KM | EAST - 1727<br>WEST - 3418 | EAST - 456<br>WEST - 764 | INNERZONE - 1000<br>OUTERZONE - 1258 | 5.145<br>6.472 |
| #2 Kingston Sub. Mile 324.98 - 312.0 (12.98MI) 20.9KM | EAST - 25<br>WEST - NIL | EAST - 120<br>WEST - NIL | INNERZONE - 1053<br>OUTERZONE - 1359 | 0.026<br>0.033 |
| #3 Kingston Sub. Mile 332.4 - 325.0 (7.41MI) 11.9KM | EAST - NIL<br>WEST - NIL | EAST - NIL<br>WEST - NIL | INNERZONE - 3529<br>OUTERZONE - 5042 | --<br>-- |
| #4 York Sub. Mile 14.0 - 0.0 (14.0MI) 22.5KM | EAST - 1727<br>WEST - 3282 | EAST - 456<br>WEST - 695 | INNERZONE - 123<br>OUTERZONE - 201 | 0.616<br>1.007 |
| #5 York Sub. Mile 18.4 - 14.0 (4.4MI) 7.1KM | EAST - 1727<br>WEST - 3282 | EAST - 456<br>WEST - 695 | INNERZONE - 789<br>OUTERZONE - 1033 | 3.952<br>5.174 |

TABLE 9/2

DANGEROUS COMMODITIES AND POPULATION DENSITY -- CNR

| Corridor # | Volume of Dangerous Commodities Handled In Cars 6 Month Period | Number of Trains In 6 Month Period | Population Density Per Square Km. | Relative Risk Index |
|---|---|---|---|---|
| #6 York Sub. Mile 23.6 - 18.4<br>(5.2 MI)<br>8.4 KM | EAST - 4247<br>WEST - 4025 | EAST - 1301<br>WEST - 891 | INNERZONE - 771<br>OUTERZONE - 929 | 6.378<br>7.684 |
| #7 York Sub. Mile 25.2 - 23.6<br>(1.6 MI)<br>2.6 KM | EAST - 4923<br>WEST - 4030 | EAST - 1573<br>WEST - 891 | INNERZONE - 177<br>OUTERZONE - 187 | 1.583<br>1.672 |
| #8 Halton Sub. Mile 11.1 - 0.0<br>(11.1 MI)<br>17.9 KM | EAST - 5201<br>WEST - 895 | EAST - 938<br>WEST - 419 | INNERZONE - 425<br>OUTERZONE - 642 | 2.591<br>3.913 |
| #9 Halton Sub. Mile 20.7 11.1<br>(9.6 MI)<br>15.4 KM | EAST - 5161<br>WEST - 558 | EAST - 754<br>WEST - 147 | INNERZONE - 871<br>OUTERZONE - 736 | 4.981<br>4.209 |
| #10 Uxbridge Sub. Mile 51.1 - 39.0<br>(12.1 MI)<br>19.4 KM | EAST - NIL<br>WEST - NIL | EAST - NIL<br>WEST - NIL | INNERZONE - 66<br>OUTERZONE - 262 | --<br>-- |

TABLE 9/3

DANGEROUS COMMODITIES AND POPULATION DENSITY -- CNR

| Corridor # | Volume of Dangerous Commodities Handled In Cars 6 Month Period | Number of Trains In 6 Month Period | Population Density Per Square Km. | Relative Risk Index |
|---|---|---|---|---|
| #11 Uxbridge Sub. Mile 60.9 - 51.1 (9.8 MI) 15.8 KM | EAST - NIL<br>WEST - NIL | EAST - NIL<br>WEST - NIL | INNERZONE - 383<br>OUTERZONE - 1533 | --<br>-- |
| #12 Bala Sub. Mile 31.2 - 16.0 (15.2 MI) 24.4 KM | NORTH - 1825<br>SOUTH - 184 | NORTH - 409<br>SOUTH - 78 | INNERZONE - 611<br>OUTERZONE - 695 | 1.227<br>1.396 |
| #13 Bala Sub. Mile 16.0 - 1.9 (14.1 MI) 22.7 KM | NORTH - 559<br>SOUTH - 702 | NORTH - 128<br>SOUTH - 438 | INNERZONE - 1454<br>OUTERZONE - 2643 | 1.833<br>3.332 |
| #14 Newmarket Sub. Mile 27.4 - 12.9 (14.5 MI) 23.3 KM | NORTH - 72<br>SOUTH - NIL | NORTH - 57<br>SOUTH - NIL | INNERZONE - 127<br>OUTERZONE - 143 | .009<br>.010 |
| #15 Newmarket Sub. Mile 12.9 - 2.4 (10.5 MI) 16.9 KM | NORTH - NIL<br>SOUTH - 609 | NORTH - NIL<br>SOUTH - 280 | INNERZONE - 3195<br>OUTERZONE - 3994 | 1.946<br>2.432 |

TABLE 9/4

DANGEROUS COMMODITIES AND POPULATION DENSITY -- CNR

| Corridor # | Volume of Dangerous Commodities Handled In Cars 6 Month Period | Number of Trains In 6 Month Period | Population Density Per Square Km. | Relative Risk Index |
|---|---|---|---|---|
| #16 Weston Sub. Mile 0.0 - 17.0 (17.0 MI) 27.4 KM | EAST - 340<br>WEST - NIL | EAST - 264<br>WEST - NIL | INNERZONE - 1533<br>OUTERZONE - 2313 | 0.521<br>0.786 |
| #17 Oakville Sub. Mile 1.1 - 8.4 (7.3 MI) 11.75 KM | EAST - 1552<br>WEST - 551 | EAST - 457<br>WEST - 318 | INNERZONE - 2170<br>OUTERZONE - 2713 | 3.368<br>1.495 |
| #18 Oakville Sub. Mile 8.4 - 27.1 (18.7 MI) 30.1 KM | EAST - 4022<br>WEST - 2829 | EAST - 649<br>WEST - 649 | INNERZONE - 884<br>OUTERZONE - 1131 | 3.555<br>3.199 |
| | | | | |
| | | | | |

TABLE 10/1

DANGEROUS COMMODITIES AND POPULATION DENSITY -- CPR

| Corridor # | Volume of Dangerous Commodities Handled In Cars 6 Month Period | Number of Trains In 6 Month Period | Population Density Per Square Km. | Relative Risk Index |
|---|---|---|---|---|
| #19 Belleville Sub. Mile 196.0 - 181.48 (14.52 MI) 23.4 KM | EAST - 2379<br>WEST - 306 | EAST - 240<br>WEST - 96 | INNERZONE - 21<br>OUTERZONE - 144 | 0.056<br>0.386 |
| #20 Belleville Sub. Mile 206.0 - 196.0 (10.0 MI) 16.1 KM | EAST - 3354<br>WEST - 1248 | EAST - 540<br>WEST - 420 | INNERZONE - 932<br>OUTERZONE - 2795 | 4.289<br>12.862 |
| #21 Belleville Sub. Mile 211.5 - 206.0 (5.5 MI) 8.9 KM | EAST - 42<br>WEST - 36 | EAST - 26<br>WEST - 22 | INNERZONE - 1348<br>OUTERZONE - 3371 | 0.105<br>0.262 |
| #22 Havelock Sub. Mile 179.0 - 161.33 (17.67 MI) 28.4 KM | EAST - 24<br>WEST - 0 | EAST - 17<br>WEST - 0 | INNERZONE - 8<br>OUTERZONE - 23 | 0.0002<br>0.0005 |
| #23 North Toronto Sub. Mile 5.9 - 0.0 (5.9 MI) 9.5 KM | EAST - 4329<br>WEST - 1566 | EAST - 648<br>WEST - 420 | INNERZONE - 4421<br>OUTERZONE - 4737 | 26.062<br>27.924 |

TABLE 10/2

DANGEROUS COMMODITIES AND POPULATION DENSITY -- CPR

| Corridor # | Volume of Dangerous Commodities Handled In Cars 6 Month Period | Number of Trains In 6 Month Period | Population Density Per Square Km. | Relative Risk Index |
|---|---|---|---|---|
| #24 Galt Sub. Mile 9.6 - 4.9<br>(4.7 MI)<br>7.6 KM | EAST - 5337<br>WEST - 657 | EAST - 492<br>WEST - 396 | INNERZONE - 3553<br>OUTERZONE - 4934 | 21.296<br>29.574 |
| #25 Galt Sub. Mile 25.87 - 9.6<br>(16.27 MI)<br>27.2 KM | EAST - 3942<br>WEST - 2736 | EAST - 336<br>WEST - 228 | INNERZONE - 817<br>OUTERZONE - 1164 | 5.456<br>7.773 |
| #26 Galt Sub. Mile 4.9 - 2.3<br>(2.6 MI)<br>4.2 KM | EAST - 810<br>WEST - 471 | EAST - 168<br>WEST - 120 | INNERZONE - 5714<br>OUTERZONE - 7143 | 7.319<br>9.150 |
| #27 Mactier Sub. Mile 32.5 - 0.0<br>(32.5 MI)<br>52.3 KM | SOUTH - 3144<br>NORTH - 1977 | SOUTH - 120<br>NORTH - 312 | INNERZONE - 37<br>OUTERZONE - 124 | 0.189<br>0.635 |
| #28 Canpa Sub. Mile 2.6 - 0.0<br>(2.6 MI)<br>4.2 KM | SOUTH - 2280<br>NORTH - 2472 | SOUTH - 156<br>NORTH - 156 | INNERZONE - 714<br>OUTERZONE - 1786 | 3.393<br>8.487 |

TABLE 11

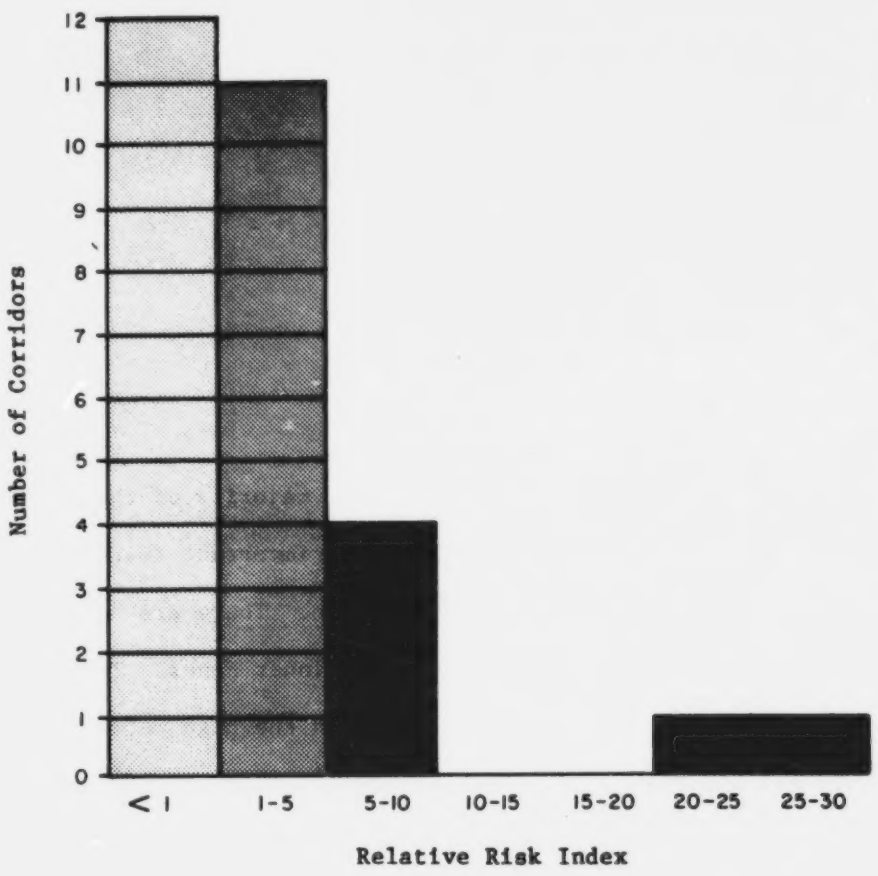
The Distribution Of Corridors By Value Of The Relative Risk Index

| Value of Index | Inner Zone | Outer Zone |
|---|---|---|
| < 1 | 12 | 11 |
| 1 - 5 | 11 | 9 |
| 5 - 10 | 4 | 6 |
| 10 - 15 | 0 | 1 |
| 15 - 20 | 0 | 0 |
| 20 - 25 | 1 | 0 |
| > 25 | 1 | 2 |

This frequency distribution shows that the large majority of the 29 corridors have relatively low risk index values. The most important feature of Table 11 however is the bimodal nature of the distribution. There are no corridors with risk index values in the 10 - 20 range for inner zones. This is shown graphically in Figure 11. The two corridors with the high relative risk index are numbers 23 and 24 on the C.P. network, corresponding to the North Toronto Subdivision and part of the Galt Subdivision. It was this route that the C.P. train that derailed at Mississauga was following. As measured by the number of passing carloads of dangerous commodities and density of population, those two corridors have substantially greater risk than any other parts of the rail network in the Toronto CMA.

Figure 11

FREQUENCY OF CORRIDORS
BY RELATIVE RISK INDEX
INNER ZONE



It is again worth repeating that this does not signify anything about the absolute level of risk, only that it is relatively higher.

The relative risk index is used as a basis for Figures 12 and 13. Here for the Inner and Outer Zones respectively, the corridors are identified by relative risk index values. The higher values for Corridors 23 and 24 are again shown. Although traffic is heavy along the Halton and York Subdivisions of the CNR (Corridors 4,5,6,7, and 8) the relative risk index is low due to the much lower density of population.

The relative risk index reflects the residential population of the inner and outer zones. It does not take into account therefore the daytime population of the corridors. It is likely that a relative risk index based on daytime population would have high values in the corridors close to the downtown area of the City and along the lakeshore. The consequences of an accident can vary considerably as we have seen according to the time of its occurrence.

Figure 12

RELATIVE RISK INDEX BY CORRIDORS
INNER ZONE

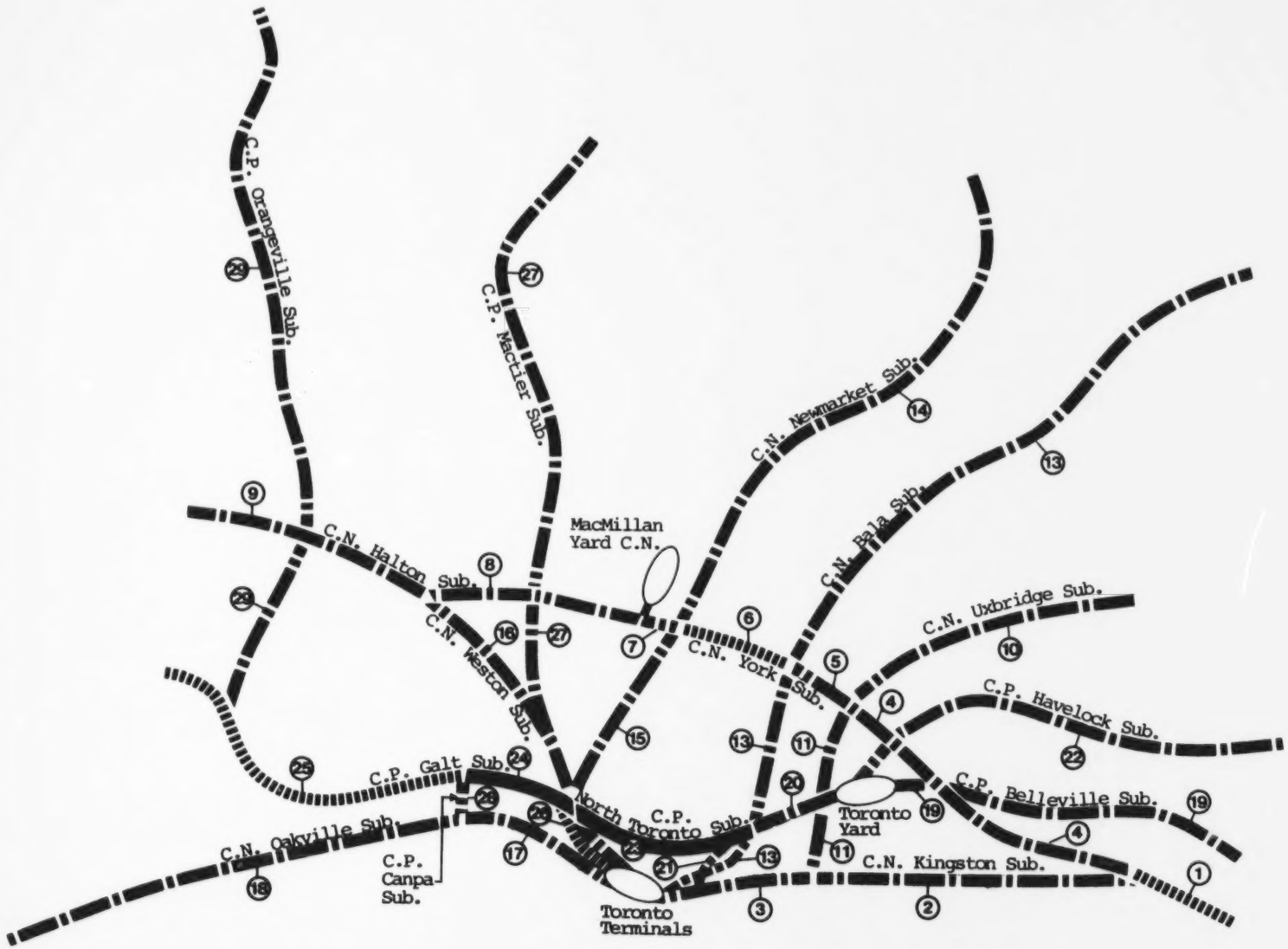
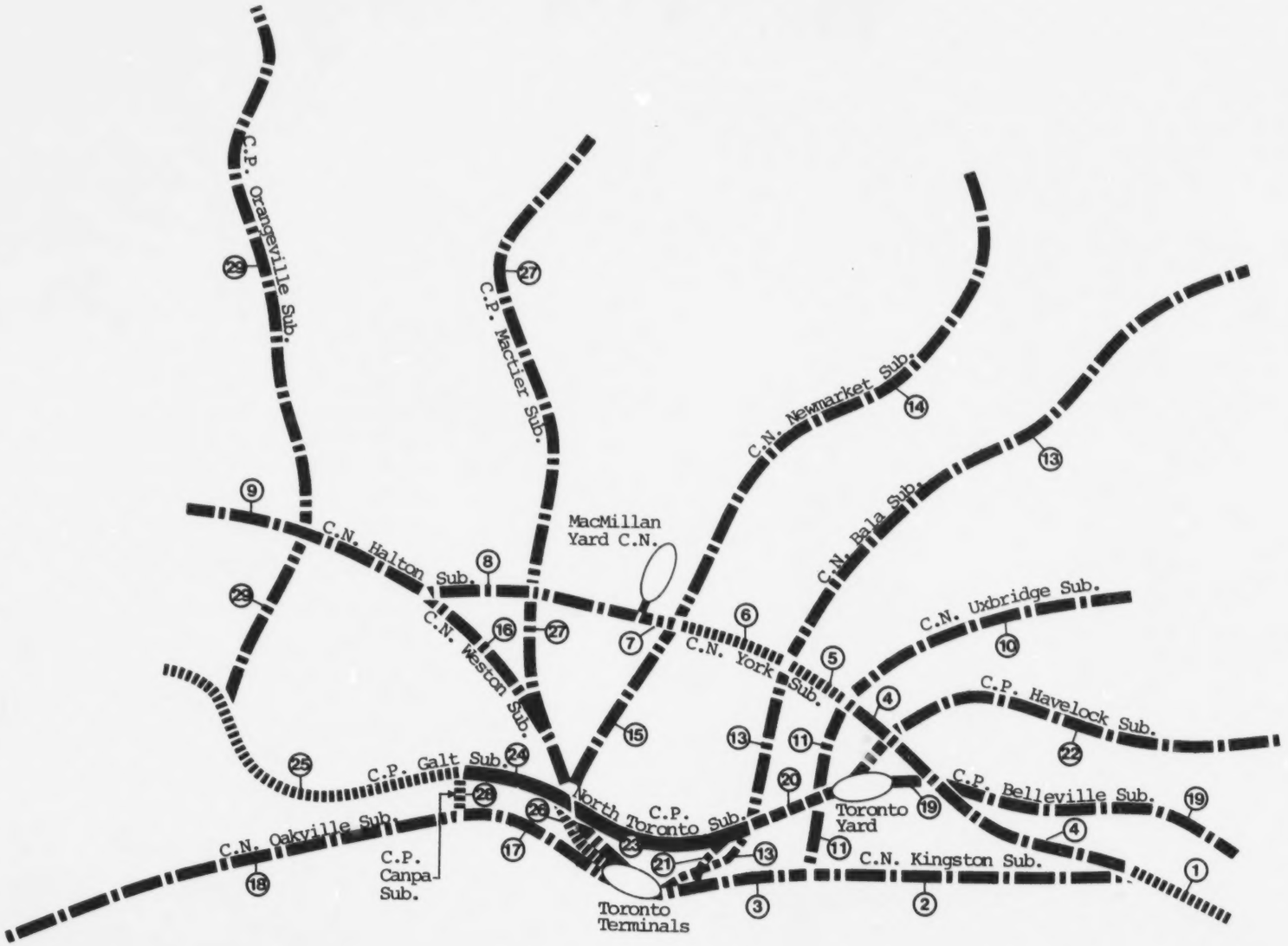


Figure 13

RELATIVE RISK INDEX BY CORRIDORS
OUTER ZONE




Relative Risk Index

- < 5
- 5 - 10
- 10 - 15
- 15 - 20
- > 20

4. Other Consequence Factors

The consequence factors described in this section are only a few of the large number of variables that would affect the magnitude of loss in the event of a major accident.

Weather conditions could be crucially important and ways need to be found of incorporating weather probabilities into risk estimates, for those commodities where this is an important risk factor.

The population density is undoubtedly the best indicator of the relative magnitude of possible consequences, but even this is subject to some severe limitations. The data provided indicates resident populations. It does not include people who may be temporarily present in the inner or outer zones for other reasons. For example, the non-resident population of some areas may include many school children, or many workers in factories, offices, or commercial establishments. The inner zone in particular contains many industrial establishments which could seriously complicate the secondary consequences of an accident should they become involved.

If the precise identifications of danger spots is of sufficient concern, it should be possible to develop a refined model of possible consequences. For many purposes, however, it will no doubt remain sufficient to have a generalised view of possible consequences over large sections of the rail network. This would be improved if done for specific commodities.

# V THE ACCIDENT RECORD

The data presented in Section III clearly indicate that substantial quantities of dangerous commodities now flow through the Toronto CMA on the rail network. The data presented in Section IV show that large number of people are at risk if a major accident and release of one or more dangerous commodities should occur. The data has been analyzed and presented in such a fashion that the relative risk between one part of the rail network and another can be appreciated.

These largely descriptive accounts are helpful in gaining an impression of relative risk. They tell nothing about the actual degree of risk. For that more complete risk modelling is required. The best indicators that can be obtained are by the use of historical accident data. The limitations of the historical approach have been described in Section II.

Accident data have been obtained for the 8 year period 1974-81. A national summary is presented in Table 12. This is for all types of accidents and shows a total of 4,347 in 1981 compared with 5,306 in 1974. There thus appears to be a modest downward trend in total rail accidents over the period. Since the total volume of rail traffic has been increasing the accident rate is also down. This impression is borne out by the associated statistics on deaths and injuries to passengers, employees and others.

The data for accidents involving dangerous commodities do not show a similar decline (Table 13). The number of derailments (131 in 1981 compared with 31 in 1974) and collisions (57 in 1981 compared to 7 in 1974) both appear to be sharply up. This is partially due to more complete reporting. The Railway Transport Committee issued a new order on 5 May 1980 (Order No. R-30846) requiring a more complete reporting of accidents and incidents involving dangerous commodities. This accounts for much of the increase in 1980 and 1981, but the figures for the years 1974 to 1979 appear to show an increase even though a more modest one. Since special care is taken in the transport of dangerous commodities, it is to be expected the trains carrying dangerous goods would be less likely to be involved in accidents than other trains. The obvious explanation is that the quantity of dangerous goods being transported by rail is going up. Transport Canada data show a 9% increase over the two years from 1978 to 1980, increased traffic may be the main explanation. (Transport Canada 1982 pg. 8). There is some evidence therefore to suppose that the risk of accidents involving dangerous commodities is increasing, perhaps as a result of higher volume of traffic.

In 1981, the total number of accidents involving dangerous commodities in Canada was 191 including 131 derailments, 57 collisions and 3 crossing accidents. Releases of dangerous commodities occurred in 10 cases, 8 of them in derailments and one each in crossing accidents and collisions. As shown in Table 14, 5 of the accidents occurred in Toronto in 1981 with no resulting product releases.

Two of the 5 occurred in the Oakville Marshalling Yard and the other 3 were derailments.

Does the actual number of accidents occurring in the Toronto Census Metropolitan Area reflect what might be expected considering the overall accident rate in Canada? This question would be most accurately addressed in terms of the distribution of carload/km of dangerous commodities in Canada and in Toronto. Unfortunately, data or trip length are not to hand and since trip length can be presumed to vary considerably between Canada (national statistics) and Toronto (local data), the comparison cannot properly be made. It is possible, however, to compare actual and expected accidents per mile of track.

1. Accidents per mile of track

There are 37,834 miles of main line railway track in Canada. If accidents are equally probable on any mile of track then the probability of an accident involving dangerous commodities, on any given mile of track in 1981 can be stated as:

$$\frac{191 \text{ (accidents}}{37{,}834 \text{ (miles}} = 0.005$$

At least two factors are likely to seriously distort this estimate. Not all main line track carries dangerous goods and some sections of track are likely to have a lot of such cargo while others have very little.

TABLE 12 NATIONAL SUMMARY OF RAILWAY ACCIDENTS

1974 - 82

| | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|---|
| Number of Accidents | 5,306 | 5,073 | 4,703 | 4,284 | 4,578 | 4,591 | 4,316 | 4,347 |
| Casualties | | | | | | | | |
| i) Passengers | | | | | | | | |
| killed | 1 | - | - | 1 | - | - | - | 1 |
| injured | 813 | 484 | 523 | 324 | 420 | 400 | 334 | 460 |
| ii) Employees | | | | | | | | |
| killed | 24 | 23 | 8 | 7 | 9 | 10 | 10 | 8 |
| injured | 2,855 | 2,764 | 2,940 | 2,754 | 2,909 | 3,358 | 3,137 | 3,141 |
| iii) Others | | | | | | | | |
| killed | 236 | 164 | 173 | 134 | 143 | 141 | 179 | 143 |
| injured | 681 | 627 | 590 | 403 | 437 | 453 | 428 | 404 |
| TOTAL | | | | | | | | |
| killed | 261 | 187 | 182 | 141 | 152 | 151 | 191 | 152 |
| injured | 4,439 | 3,875 | 4,053 | 3,481 | 3,766 | 4,211 | 3,899 | 4,005 |
| Classification Groups | | | | | | | | |
| Collisions | 73 | 82 | 64 | 63 | 81 | 66 | 97 | 115 |
| Derailments | 427 | 358 | 332 | 320 | 300 | 350 | 303 | 350 |
| Crossing Accidents | 1,074 | 982 | 923 | 877 | 871 | 937 | 826 | 763 |
| Track Motor Accidents | 60 | 50 | 39 | 55 | 55 | 48 | 60 | 55 |
| Fires | 492 | 534 | 63* | 37* | 11* | 17* | 13* | 46* |
| Train Service | 79 | 42 | 84 | 52 | 51 | 47 | 32 | 27 |
| Personal Injuries | 2,990 | 2,941 | 3,148 | 2,810 | 3,157 | 3,044 | 2,808 | 2,882 |
| Trespassing Accidents | 87 | 112 | 84 | 82 | 105 | 82 | 177 | 109 |

* Figures do not include right-of-way fires.

Source: Summary of Accidents - Incidents Reported to the Canadian Transport Commission. Year 1981 Prepared for the Railway Transport Committee by the Safety and Services Branch, Ottawa, 1982.

TABLE 13 RAILWAY ACCIDENTS AND INCIDENTS
INVOLVING DANGEROUS COMMODITIES
1974 - 1981

Incidents involving the transportation of dangerous commodities other than in train accidents.

| | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|---|
| Total Incidents | 37 | 31 | 31 | 30 | 47 | 51 | 107 | 157 |
| Casualties | | | | | | | | |
| killed | - | - | - | - | - | - | - | - |
| injured | - | - | 8 | 1 | 1 | 6 | 23 | 1 |

Train accidents where dangerous commodities made up all or a portion of a train consist and were directly involved in a mishap which resulted in loss of lading, damage to equipment, loss of man hours or contamination of the environment.

| | | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|---|---|
| a) | Derailments | 31 | 30 | 33 | 36 | 43 | 42 | 65 | 131 |
| | Casualties | | | | | | | | |
| | killed | - | - | - | - | - | - | - | - |
| | injured | - | - | - | - | 7 | 2 | - | 1 |
| b) | Collisions | 7 | 6 | 7 | 7 | 14 | 17 | 44 | 57 |
| | Casualties | | | | | | | | |
| | killed | - | - | - | - | - | - | - | - |
| | injured | - | - | - | - | - | - | - | - |
| c) | Crossings | 2 | - | 3 | 1 | - | 2 | 11 | 3 |
| | Casualties | | | | | | | | |
| | killed | - | - | - | - | - | - | 4 | - |
| | injured | - | - | - | - | - | - | 2 | 2 |

Source: Summary of Accidents - Incidents Reported to the Canadian Transport Commission. Year 1981. Prepared for the Railway Transport Committee by the Safety and Services Branch, Ottawa, 1982.

TABLE 14 TYPES AND LOCATIONS OF DANGEROUS COMMODITY ACCIDENTS 1981

| | Main Line | Yard | Total | Product Releases |
|---|---|---|---|---|
| Collisions | 9 | 48 | 57 | 1 |
| Crossings | 3 | 0 | 3 | 1 |
| Derailments | 78 | 53 | 131 | 8 |
| | 90 | 101 | 191 | 10 |

| | Toronto | Ontario | Canada |
|---|---|---|---|
| Collisions | 2 (Oakville Yard) | 5 | 57 |
| Crossings | 0 | 0 | 3 |
| Derailments | 3 | 24 | 131 |
| Product Release | 0 | 0 | 8 |
| | 5 | 29 | 191 |

Source: Safety and Services Branch
Railway Transport Committee

Assuming that only half of the total length of track is used for transporting dangerous goods, the estimate would be reduced as follows:

$$\frac{191 \text{ (accidents)}}{18{,}917 \text{ (50\% of main line track)}} = 0.01$$

Furthermore in 1981, only 78 of the 131 derailments occurred on main line tracks, and only 9 of the 57 collisions. All 3 crossing accidents involved main line track. The total number of accidents on main lines is 90. Applying this to the 50% of main line track yields

$$\frac{90 \text{ (main line accidents)}}{18{,}917 \text{ (50\% of main line track)}} = 0.0047 \text{ accidents per mile.}$$

Applying these probabilities to the length of main line track in the Toronto CMA estimated at 338.76 miles, yields the estimates in Table 15.

TABLE 15

EXPECTED ACCIDENTS ON MAIN LINE TRACK IN TORONTO CMA 1981

| Assuming Accident Probability Per Mile of Track | Expected Number Of Accidents |
|---|---|
| .005 | 1.7 |
| .01 | 3.3 |
| .047 | 1.6 |

Following the same procedure, the expected number of accidents in the Toronto Census Metropolitan Area for 1981 are calculated for collisions, crossing accidents, derailments, and product releases and shown in Table 16. These calculations show that the total number of accidents recorded in the Toronto Census Metropolitan Area in 1981 was somewhat higher than might be expected from national accident records on a "per mile of main line track" basis. The expected number of accidents is approximately 2, and 3 were recorded (5 if two yard collisions at Oakville are included).

The expected number of accidents, with dangerous product release is approximately 0.1 or 0.2. This means that at 1981 rates an accident with dangerous product release can be expected on an average once every 5 to 10 years. In fact none were recorded in 1981.

TABLE 16

EXPECTED AND RECORDED ACCIDENTS ON MAIN LINE IN TORONTO CMA 1981

| TYPE OF ACCIDENT | "EXPECTED" PROBABILITY ASSUMPTION | | | RECORDED |
|---|---|---|---|---|
| | .005 | .01 | .047 | |
| Collisions | 0.5 | 1.0 | 0.16 | 2 (in Oakville Yard) |
| Crossings | 0.02 | 0.05 | 0.05 | 0 |
| Derailments | 1.2 | 2.3 | 1.4 | 3 |
| Product Releases | 0.09 | 0.18 | 0.17 | 0 |
| Total | 1.71 | 3.35 | 1.61 | 5 (including 2 yard accidents) |

## VI RISK ASSESSMENT

What can be said by way of summary about the risks of transporting dangerous commodities by rail in the Toronto Census Metropolitan Area?

Some quantitative estimates of probabilities of accidents have been made on the basis of the national accident statistics. No detailed modelling of possible consequences has yet been made. To do this adequately would require more work on a commodity-by-commodity basis. There is a case to be made for a detailed risk analysis of a few commodities that can be presumed to be more dangerous because more frequently transported. It is not altogether reliable to assume on an "a priori" basis that propane presents higher risk because transported in larger quantities than other materials such as chlorine or radioactive substances, transported in much smaller quantities.

If weight is placed upon risk analysis of chlorine transported in the United States, the Mississauga accident is seen as a rare event. The probability of a Mississauga accident is calculated to be about six chances per million shipments of chlorine. If 3,000 carloads of chlorine are shipped per year, then the expected frequency of a chlorine tank car derailment and fire with product release in Toronto is in the order of magnitude of once per 100 years.

Consideration of the national accident records produces an expected frequency of accidents involving dangerous commodities in Toronto of about 2 per year. Dangerous commodity releases can be expected once every 5 to 10 years.

Dangerous commodity releases when they do occur rarely result in fatalities. It is usually possible to ensure that people are kept at a safe distance from the accident site and evacuated if necessary as a precautionary measure.

Assessment of risk involves both the probability of accidents and the consequences. No detailed analyses of possible consequences have been made, but little imagination is required to see that in the case of some accidents, the consequences could be severe. The increase in volume of dangerous goods being transported and the high density of residential population along some railway routes suggests that major product releases are possible in locations where many people might be exposed, and where rapid evacuation would prove difficult. Events causing the deaths of hundreds of people or more could occur.

There is a case to be made for more detailed analysis of possible consequences. While such analysis might not affect the risk assessment in any substantial way, it could demonstrate the need for emergency plans and suggest how communities might be better prepared to deal with releases of dangerous goods.

In the meantime, data has been assembled and analysed that permit conclusions to be drawn about the relative risk in different parts of the rail network. The evidence shows that substantially greater risk exists along Corridors 23 and 24 on the C.P.R. network, called the North Toronto and the Galt (part of)Subdivisions respectively. The calculated relative risk index reads much higher for those two corridors than elsewhere in the network.

The high relative risk index values for Corridors 23 and 24 reflect volume of traffic and density of residential population only. No other probability factors or consequence factors have been taken into account. This should be done if a modelling approach to risks is subsequently adopted.

Risks also exist at marshalling yards and trans-shipment points. The distribution of the latter has been identified together with the quantity and type of commodities trans-shipped, but no relative risk index has been calculated.

It is interesting to note that the areas of highest relative risk from the transportation of dangerous commodities (Corridors 23 and 24) have a lack of trans-shipment points, and classification yards.

The question to be addressed in the light of this report is -- are further efforts at risk reduction now needed and justified?

This is clearly a matter for the judgement of others than the risk analysts. It can be said,however, that the potential for serious accidents clearly exists and that it has grown up inadvertently with the growth in some risk factors. The allocation of more effort to risk reduction depends upon the acceptability of the risk as now understood and the costs of any mitigation proposed.

We therefore recommend that consideration be given to diverting the flow of special dangerous commodities off the Galt and North Toronto Subdivision of CP Rail, and re-routing them along the York Subdivision of CNR. Such re-routing will require the making of some new connections between CN and CP tracks. The feasibility of this re-routing should be examined as a matter of urgency.

We recommend this course of action because we believe that the evidence shows that there would be much lower risk if dangerous commodities were transported through less densely populated areas. We regard this as a palliative and temporary response only. There is also a need for a reassessment of railway siting and routes in the most populated areas of the province.

A Task Force (Ontario Task Force on Provincial Rail Policy 1981) recommended (p. 89) in 1981 "the re-routing of dangerous goods rail traffic around population centres. Routes through cities should be avoided where alternative routes exist, as in the case of the Toronto area". So far this recommendation appears to have led to no action after two years.

We therefore suggest that the interested parties initiate an examination of the possibility of railway relocation, so that new routes may be provided to permit the transport of dangerous commodities around population centres.

Beyond that, a question is addressed to planners and policy makers at municipal and provincial levels. We have seen that risk factor increase is to a large extent responsible for the present situation. Has the municipal level of government done enough to keep high population density away from areas of technological risk? The growth of modern suburbs close to the York Subdivision of CNR is evidence that the danger of major railway accidents has either been ignored or discounted at the municipal level. An Ontario Government report issued in 1981 deals with land use planning for noise control in residential communities. (Ontario Ministry of Municipal Affairs and Housing 1981). It should be possible to prepare similar information for risk reduction in residential communities for the guidance of planners and policy makers at the municipal level.

The adoption of a policy of keeping population at respectable distances from rail lines where dangerous commodities are being transported in large quantities needs to be addressed, but it is much too late for such a policy to have rapid or significant effect in those areas where dense populations are already found. Unless some action is taken, the risk factors will continue to increase and potential for catastrophe that already exists will become steadily greater.

APPENDIX TABLE A/1

TABLE 9/1

CROSSINGS AND TRACK DATA

| Corridor # | Mainline Crossings | | Track Data | |
|---|---|---|---|---|
| #1 Kingston Sub.<br>Mile 311.4-307.29 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 3<br>0<br>0<br>3 | Rail-115-132lb jointed and laid 1949-1963<br>Ballast - Rock<br>Ties-#2 treated 3250 per mile<br>Condition - Good<br>Control - CTC | |
| #2 Kingston Sub.<br>Mile 324.98-312.0 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 6<br>10<br>0<br>16 | Rail-115-132lb jointed and laid 1949-1963<br>Ballast - Rock<br>Ties-#2 treated 3250 per mile<br>Condition - Good<br>Control - CTC | |
| #3 Kingston Sub.<br>Mile 332.4-325.0 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 15<br>0<br>0<br>15 | Rail-115-132lb jointed and laid 1949-1963<br>Ballast - Rock<br>Ties - #2 treated 3250 per mile<br>Condition - Good<br>Control - CTC | |
| #4 York Sub.<br>Mile 14.0 - 0.0 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 13<br>5<br>0<br>18 | Rail-115-132lb jointed and laid 1962-1964<br>Ballast - Slag<br>Ties-#1 and #2 treated 3250 per mile<br>Condition - Good<br>Control - CTC | |
| #5 York Sub.<br>Mile 18.4 - 14.0 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 4<br>1<br>0<br>5 | Rail-115-132lb jointed laid 1962 to 1964<br>Ballast - Slag<br>Ties-#1 and #2 treated 3250 per mile<br>Condition - Good<br>Control - CTC | |

APPENDIX TABLE A/2
TABLE 9/2

CROSSINGS AND TRACK DATA

| Corridor # | Mainline Crossings | | Track Data | |
|---|---|---|---|---|
| #6 York Sub.<br>Mile 23.6 - 18.4 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 6<br>0<br>0<br>6 | Rail-115-132lb jointed laid 1962 to 1964<br>Ballast - Slag<br>Ties-#1 and #2 treated 3250 per mile<br>Condition - Good<br>Control - CTC | |
| #7 York Sub.<br>Mile 25.2 - 23.6 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 1<br>0<br>0<br>1 | Rail-115-132lb jointed laid 1962 - 1964<br>Ballast - Slag<br>Ties-#1 and #2 treated 3250 per mile<br>Condition - Good<br>Control - CTC | |
| #8 Halton Sub.<br>Mile 11.1 - 0.0 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 11<br>3<br>0<br>14 | Rail-115-132lb jointed and continuous welded laid 1962 to 1982<br>Ballast - Slag<br>Ties - #2 treated 3250 per mile<br>Condition - Good<br>Control - CTC | |
| #9 Halton Sub.<br>Mile 20.7 - 11.1 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 7<br>9<br>2<br>18 | Rail-115-132lb jointed and continuous welded laid 1962 to 1982<br>Ballast - Slag<br>Ties-#2 treated 2840 per mile<br>Condition - Good<br>Control - CTC | |
| #10 Uxbridge Sub.<br>Mile 51.1 - 39.0 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 0<br>9<br>4<br>13 | Rail-100-132lb jointed laid 1924 - 1955<br>Ballast - Rock<br>Ties-#2 treated 2840 per mile<br>Condition - Adequate<br>Control - Train Order MI 39.0 to 50.9<br>CTC MI. 50.9 to 51.1 | |

APPENDIX TABLE A/3
TABLE 9/3

CROSSINGS AND TRACK DATA

| Corridor # | Mainline Crossings | | Track Data | |
|---|---|---|---|---|
| #11 Uxbridge Sub.<br>Mile 60.9 - 51.1 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 2<br>11<br>2<br>15 | Rail-100-132lb jointed laid 1924 - 1955<br>Ballast - Rock<br>Ties-#2 treated 2840 per mile<br>Condition - Adequate<br>Control-CTC MI 50.9 - 51.4 Train Order MI51.4 -60.9 | |
| #12 Bala Sub.<br>Mile 31.2 - 16.0 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 5<br>22<br>0<br>27 | Rail-115-132lb jointed and continuous welded laid 1951 - 1978<br>Ballast - Slag<br>Ties-#1 treated 3250 per mile<br>Condition - Good<br>Control - CTC | |
| #13 Bala Sub.<br>Mile 16.0 - 1.9 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 18<br>2<br>0<br>20 | Rail-115-132lb jointed and continuous welded laid 1951 - 1978<br>Ballast - Slag<br>Ties-#1 Treated 3250 per mile<br>Condition - Good<br>Control - CTC | |
| #14 Newmarket Sub.<br>Mile 27.4 - 12.9 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 7<br>8<br>0<br>15 | Rail-100-115lb jointed and/or continuous welded laid 1953 - 1975<br>Ballast - Slag<br>Ties-#1 and #2 treated 3250 per mile<br>Condition - Good<br>Control-CTC MI 15.5 to 12.9 Train Order MI 40.4 to 12.9 | |
| #15 Newmarket Sub.<br>Mile 12.9 - 2.4 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 14<br>3<br>1<br>18 | Rail-100-115lb jointed and/or continuous welded slag<br>Ballast-MI 2.4-8.0<br>MI 8.0-12.9 rock<br>Ties-#1 and #2 treated 3250 per mile<br>Condition - Good<br>Control - CTC | |

APPENDIX TABLE A/4
TABLE 9/4

CROSSINGS AND TRACK DATA

| Corridor # | Mainline Crossings | | Track Data | |
|---|---|---|---|---|
| #16 Weston Sub.<br>Mile 0.0 - 17.0 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 21<br>12<br>0<br>33 | Rail-100-115lb jointed and continuous welded laid 1950 - 1973<br>Ballast - Rock<br>Ties - #2 treated 2840 per mile<br>Condition - Adequate<br>Control - CTC | |
| #17 Oakville Sub.<br>Mile 1.1 - 8.4 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 17<br>0<br>0<br>17 | Rail TK1-100 & 132lb. jointed and continuous welded laid 1950-1979<br>TK2-132lb jointed and continuous welded laid 1950-1979<br>TK3-130 & 132lb jointed and continuous welded laid 1954 - 1960<br>TK4-100,130 & 132 lb. jointed and continuous welded laid 1950-1978<br>Ballast - Rock<br>Ties-#2 treated 3250 per mile<br>Condition - Good<br>Control - CTC | |
| #18 Oakville Sub.<br>Mile 8.4 - 27.1 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 11<br>15<br>0<br>26 | | |
| | | | | |

APPENDIX TABLE B/1
TABLE 10/1

CROSSINGS AND TRACK DATA BY CORRIDORS - CPR

| Corridor # | Mainline Crossings | | Track Data | |
|---|---|---|---|---|
| #19 Belleville Sub.<br>Mile 196.0 - 181.48 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 8<br>10<br>2<br>20 | Rail-115-132lb continuous welded laid 1969 - 1982<br>Ballast - Slag<br>Ties-#1 treated 3160 per mile<br>Condition - Good<br>Control - CTC | |
| #20 Belleville Sub.<br>Mile 206.0 - 196.0 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 13<br>2<br>0<br>15 | Rail-115-132lb continuous welded laid 1969-1982<br>Ballast - Slag<br>Ties - #1 treated 3160 per mile<br>Condition - Good<br>Control - CTC | |
| #21 Belleville Sub.<br>Mile 211.5 - 206.0 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 8<br>0<br>0<br>8 | Rail-115-132lb continuous welded laid 1969-1982<br>Ballast - Slag<br>Ties-#1 treated 3160 per mile<br>Condition - Good<br>Control - CTC | |
| #22 Havelock Sub.<br>Mile 179.0 - 161.33 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 1<br>17<br>7<br>25 | Rail-100lb jointed laid 1932-1961<br>Ballast-Gravel and isolated area of slag<br>Ties-#2 treated 1905 per mile<br>Condition - Adequate<br>Control - Train Orders | |
| #23 North Toronto Sub.<br>Mile 5.9 - 0.0 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 17<br>2<br>0<br>19 | Rail-130lb continuous welded laid 1971<br>Ballast - Rock<br>Ties - mixed #1 hard & softwood treated 2880 per mile<br>Condition-Adequate<br>Control - CTC<br>**NOTE: 1983 Tie renewal and respacing at 20" and reballasting with slag.** | |

APPENDIX TABLE B/2
TABLE 10/2

CROSSINGS AND TRACK DATA

| Corridor # | Mainline Crossings | | Track Data | |
|---|---|---|---|---|
| #24 Galt Sub.<br>Mile 9.6 - 4.9 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 8<br>0<br>0<br>8 | Rail-136lb continuous welded laid 1981<br>Ballast - Slag<br>Ties-#1 treated 3160 per mile<br>Condition - Good<br>Control - CTC | |
| #25 Galt Sub.<br>Mile 25.87 - 9.6 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 8<br>15<br>3<br>26 | Rail-136lb continuous welded laid 1980<br>Ballast - Slag<br>Ties-#1 treated 3160 per mile<br>Condition - Good<br>Control - CTC | |
| #26 Galt Sub.<br>Mile 4.9 - 2.3 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 8<br>0<br>0<br>8 | Rail-136lb continuous welded laid 1981<br>Ballast - Slag<br>Ties-#1 treated 3160 per mile<br>Condition - Good<br>Control - Automatic Block System | |
| #27 Mactier Sub.<br>Mile 32.5 - 0.0 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 22<br>24<br>0<br>46 | Rail-115lb continuous welded rail from 0.0 - 10.2 laid 1982 - 115lb jointed from 10.2-32.5<br>Ballast - Slag<br>Ties-#1 treated 3017 per mile. Condition-Good<br>Control-mile 0.0-20.0 CTC; mile 20.0-32.5 ABS | |
| #28 Canpa Sub.<br>Mile 2.6 - 0.0 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 2<br>4<br>0<br>6 | Rail-100lb jointed laid 1966<br>Ballast - Rock<br>Ties-#2 treated soft-wood 2880 per mile<br>Condition - Adequate<br>Control - Train Orders | |

APPENDIX TABLE B/3
TABLE 10/3

CROSSINGS AND TRACK DATA

| Corridor # | Mainline Crossings | | Track Data | |
|---|---|---|---|---|
| #29 Orangeville Sub.<br>Mile 34.6 - 0.0 | Grade Separations<br>Flashing lights & Bell &/ or Gates<br>Reflector Crossing Signs | 6<br>21<br>14<br>41 | Rail-MI 0.32 MI 9.23 - 16.26 MI 22.35 - 27.67 is 85lb jointed rail. Balance is 100lb jointed. Ballast - Gravel.<br>Ties - 2904 per mile<br>Condition - Fair<br>Control - Train Orders | |
| | | | | |
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| | | | | |
| | | | | |

APPENDIX TABLE C/1

TABLE 11/1

TRAIN SPEEDS AND INSPECTION PROCEDURES BY CORRIDORS -- CNR

| Corridor # | East or North Movements | | West or South Movements | |
|---|---|---|---|---|
| | Maximum Speeds | Special Instructions | Maximum Speeds | Special Instructions |
| #1 Kingston Sub.<br>Mileage 311.4 - 307.29 | Mile 311.4 - 307.29 PASS 90 / FRT 60 | DANGEROUS COMMODITIES<br>Limit 35 MPH between 311.4 and 307.29 | Mile 307.29 - 311.4 PASS 90 / FRT 60 | DANGEROUS COMMODITIES<br>Limit 35 MPH between 307.29 and 311.4 |
| #2 Kingston Sub.<br>Mileage 324.98 - 312.0 | Mile 324.98 - 312.0 PASS 90 / FRT 60 | Mile 322.6 - 322.2 PASS 80 / FRT 60<br>Mile 318.8 - 318.4 PASS 80 / FRT 60<br>DANGEROUS COMMODITIES<br>Inspection point between 325.0 & 321.0. If no inspection 15MPH limit between 321.0 & 312.0<br>Mile 324.98 - 312.0 Limit 35 MPH | Mile 312.0 - 324.98 PASS 90 / FRT 60 | Mile 322.2 - 322.6 PASS 80 / FRT 60<br>DANGEROUS COMMODITIES<br>Inspection point between 321.0 - 325.0. If no inspection 15 MPH between 325.0 & 324.98.<br>Mile 312.0 - 324.98 Limit 35 MPH |
| #3 Kingston Sub.<br>Mileage 332.4 - 325.0 | Mile 332.4 - 331.0 PASS 60 / FRT 60<br>Mile 331.0 - 325.0 PASS 90 / FRT 60 | DANGEROUS COMMODITIES<br>Speed limit 35 MPH between 332.4 & 325.0 | Mile 325.0 - 331.0 PASS 90 / FRT 60<br>Mile 331.0 - 332.4 PASS 60 / FRT 60 | DANGEROUS COMMODITIES<br>Speed limit 35MPH between 325.0 & 332.4. Inspection point between 321.0-325.0. If no inspection 15MPH between 325.0 & 332.4. |
| #4 York Sub.<br>Mileage 14.0 - 0.0 | Mile 14.0 - 0.0 All Trains 50MPH | Mile 12.3 All trains 45 MPH<br>DANGEROUS COMMODITIES<br>Limit 35MPH between mile 14.0 and 0.0. If no inspection between mile 14.0 & 5.0 speed limit between 5.0 York Sub. and 305.0 Kingston Sub. is 15 MPH. | Mile 0.0 - 14.0 All trains 50 MPH | Mile 12.3 All trains 45 MPH<br>DANGEROUS COMMODITIES<br>Limit 35MPH between 0.0 and 14.0. If no inspection between 5.0 & 14.0 speed limit between 14.0 & 25.2 is 15 MPH. |
| #5 York Sub.<br>Mileage 18.4 - 14.0 | Mile 18.0 - 14.0 All Trains 50MPH | DANGEROUS COMMODITIES<br>Limit 35MPH between 18.0 and 14.0. | Mile 14.0 - 18.0 All trains 50 MPH | DANGEROUS COMMODITIES<br>Limit 25MPH between 14.0 and 18.0. If no inspection between 5.0 and 14.0, limit between 14.0 and 18.0 is 15 MPH. |

APPENDIX TABLE C/2

TRAIN SPEEDS AND INSPECTION PROCEDURES

| Corridor # | East or North Movements | | West or South Movements | |
|---|---|---|---|---|
| | Maximum Speeds | Special Instructions | Maximum Speeds | Special Instruction |
| #6 York Sub.<br>Mile 23.6 - 18.4 | Mile 23.6 - 18.0 All Trains 50MPH | DANGEROUS COMMODITES<br>Limit 35MPH between 23.6 and 18.0 | Mile 18.0 and 23.6 All Train 50MPH | DANGEROUS COMMODITIES<br>Limit 35MPH between 18.0 and 23.6. If no inspection between 5.0 and 14.0. Speed limit between 18.0 and 23.6 is 15 MPH. |
| #7 York Sub.<br>Mile 25.2 - 23.6 | Mile 25.2 - 23.6 All Trains 30MPH | DANGEROUS COMMODITES<br>Limit 30 MPH between 25.2 and 23.6. | Mile 23.6 - 25.2 All Trains 30 MPH | DANGEROUS COMMODITIES<br>Limit 30 MPH between 23.6 and 25.2. If no inspection between 5.0 and 14.0 speed limit between 18.0 and 23.6 is 15 MPH. |
| #8 Halton Sub.<br>Mile 11.1 - 0.0 | Mile 11.1 - 0.7 < PASS 50 / FRT 50<br>Mile 0.7 - 0.0 < PASS 20 / FRT 20 | Mile 4.6 - 4.4 < PASS 40 / FRT 40<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 11.1 & 1.0. If no inspection between 21.0 & 17.0 speed limit between 11.2 & 1.0 is 15 MPH. From Guelph Sub. If no inspection made between 21.0 and 4.0 speed limit between 4.0 and 1.0 is 15MPH. | Mile 0.0 - 0.7 < PASS 20 / FRT 20<br>Mile 0.7 - 11.1 < PASS 50 / FRT 50 | Mile 4.4 - 4.6 < PASS 40 / FRT 40<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between mile 1.0 & 11.1 |
| #9 Halton Sub.<br>Mile 20.7 - 11.1 | Mile 14.2 - 11.2 < PASS 60 / FRT 55<br>Mile 15.7 - 14.2 < PASS 50 / FRT 50<br>Mile 20.7 - 15.7 < PASS 70 / FRT 55 | Mile 14.2 / Mile 15.2 — PASS 45 / FRT 45<br>DANGEROUS COMMODITIES<br>Speed limit 35 MPH between 20.7 & 11.1. If not inspected between 21.0 and 17.0 speed limit between 17.0 and 11.2 is 15MPH. | Mile 11.2 - 14.2 < PASS 60 / FRT 55<br>Mile 14.2 - 15.7 < PASS 50 / FRT 50<br>Mile 15.7 - 20.7 < PASS 70 / FRT 55 | Mile 14.2 / Mile 15.2 — PASS 45 / FRT 45<br>DANGEROUS COMMODITIES<br>Speed limit between 11.2 & 20.7 is 35MPH |
| #10 Uxbridge Sub.<br>Mile 51.1 - 39.0 | Mile 51.3 - 50.9 < PASS 35 / FRT 25<br>Mile 50.9 - 47.4 < PASS 50 / FRT 25<br>Mile 47.4 - 46.9 < PASS 25 / FRT 25<br>Mile 46.9 - 41.1 < PASS 50 / FRT 25<br>Mile 41.1 - 39.0 < PASS 40 / FRT 25 | DANGEROUS COMMODITIES<br>Speed limit between 51.3 & 39.0 is 35MPH from Scarboro enroute MacMillan Yard. Inspect at mile 51.5 from MacMillan Yard enroute west of Hagerman on Uxbridge Sub. Inspect at Mile 51.5<br>From MacMillan Yard enroute east of Hagerman inspection at mile 22.0 York Sub and Mile 42.0 Uxbridge Sub. If no inspection speed limit is 15MPH between Mile 42.0 and 39.0 Uxbridge Sub. | Mile 39.0 - 41.1 < PASS 40 / FRT 25<br>Mile 41.1 - 46.9 < PASS 50 / FRT 25<br>Mile 46.9 - 47.4 < PASS 25 / FRT 25<br>Mile 47.4 - 50.9 < PASS 50 / FRT 25<br>Mile 50.9 - 51.3 < PASS 35 / FRT 25 | DANGEROUS COMMODITIES<br>Speed limit between 39.0 and 51.1 is 35 MPH. Inspect at mile 35.0 and thereafter every 20 miles unless instructed by train dispatcher to operate at 15 MPH |

APPENDIX TABLE C/3

TRAIN SPEEDS AND INSPECTION PROCEDURES

| Corridor # | East or North Movements | | West or South Movements | |
|---|---|---|---|---|
| | Maximum Speeds | Special Instructions | Maximum Speeds | Special Instructions |
| #11 Uxbridge Sub.<br>Mile 60.9 - 51.1 | Mile 60.9 - 55.5 < PASS 40 / FRT 25<br>Mile 55.5 - 51.3 < PASS 50 / FRT 25 | Danforth Road Mile 60.2 < PASS 20 / FRT 20<br>DANGEROUS COMMODITIES<br>Speed limit between 60.9 & 51.3 is 35MPH from Scarboro enroute MacMillan Yd. inspect at mile 51.5 from MacMillan Yd. enroute west of Hagerman on Uxbridge Sub. inspect at mile 51.5. From MacMillan Yd. enroute East of Hagerman inspect at mile 22.0 York Sub. and Mile 42.0 Uxbridge Sub.. If no inspection speed limit is 15MPH between Mile 42.0 and 39.0 Uxbridge Sub. | Mile 51.3 - 55.5 < PASS 50 / FRT 25<br>Mile 55.5 - 51.3 < PASS 40 / FRT 20 | Danforth Road Mile 60.2 < PASS 20 / FRT 20<br>DANGEROUS COMMODITIES<br>Speed limit between 51.1 and 60.9 is 35MPH. Inspect at mile 35.0 and thereafter every 20 miles unless instructed by train dispatcher to operate at 15MPH. |
| #12 Bala Sub.<br>Mile 31.2 - 16.0 | Mile 16.0 - 25.0 < PASS 60 / FRT 50<br>Mile 25.0 - 29.8 < PASS 45 / FRT 40<br>Mile 29.8 - 43.4 < PASS 70 / FRT 60 | Mile 36.0 - 40.9 < PASS 45 / FRT 40<br>Mile 43.0 - 43.4 < PASS 60 / FRT 35<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 16.0 and 31.0. From MacMillan Yd. If not inspected between 23.0 York Sub. and 29.0 Bala Sub. Speed limit is 15MPH between 29.0 and 31.0 on Bala Sub. | Mile 43.4 - 29.8 < PASS 70 / FRT 60<br>Mile 29.8 - 25.0 < PASS 45 / FRT 40<br>Mile 25.0 - 16.0 < PASS 60 / FRT 50 | Mile 43.4 - 43.0 < PASS 60 / FRT 55<br>Mile 40.9 - 36.0 < PASS 45 / FRT 40<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 31.0 and 16.0 If no inspection between 29.0 Bala Sub. & 23.0 York Sub. Speed limit 15MPH between 23.0 & 25.2 York Sub. |
| #13 Bala Sub.<br>Mile 16.0 - 1.9 | Mile 1.9 - 2.0 < PASS 30 / FRT 25<br>Mile 2.0 - 4.5 < PASS 35 / FRT 30<br>Mile 4.5 - 6.9 < PASS 40 / FRT 35<br>Mile 6.9 - 10.0 < PASS 35 / FRT 30<br>Mile 10.0 - 13.4 < PASS 50 / FRT 40<br>Mile 13.4 - 16.0 < PASS 65 / FRT 30 | Crossing York Sub. Mile 16.1 < PASS 50 / FRT 50<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 1.9 and 16.0. If no inspection at mile 3.0 speed limit is 15MPH between 3.0 Bala Sub. and 25.2 York Sub. | Mile 16.0 - 13.4 < PASS 65 / FRT 50<br>Mile 13.4 - 10.0 < PASS 50 / FRT 40<br>Mile 10.0 - 6.9 < PASS 35 / FRT 30<br>Mile 6.9 - 4.5 < PASS 40 / FRT 35<br>Mile 4.5 - 2.0 < PASS 35 / FRT 30<br>Mile 2.0 - 1.9 < PASS 30 / FRT 25 | Crossing York Sub. Mile 16.1 < PASS 50 / FRT 50<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 16.0 and 1.9 Enroute from MacMillan Yrd. If not inspected at 3.0 speed limit is 15MPH to destination in Toronto Terminal. |
| #14 Newmarket Sub.<br>Mile 27.4 - 12.9 | Mile 12.9 - 17.9 < PASS 75 / FRT 60<br>Mile 17.9 - 33.3 < PASS 60 / FRT 50<br>Mile 33.3 - 36.4 < PASS 50 / FRT 40<br>Mile 36.4 - 40.4 < PASS 60 / FRT 50 | Mile 12.9 - 13.3 < PASS 50 / FRT 50<br>DANGEROUS COMMODITIES<br>Speed limit 35 MPH between 12.0 and 41.0. Northward movements from MacMillan Yd. not inspected between 21.0 and 31.0 speed limit 15MPH between 31.0 and 41.0. | Mile 40.4 - 36.4 < PASS 60 / FRT 50<br>Mile 36.4 - 33.3 < PASS 50 / FRT 40<br>Mile 33.3 - 17.9 < PASS 60 / FRT 50<br>Mile 17.9 - 12.9 < PASS 75 / FRT 60 | Mile 13.3 - 12.9 < PASS 50 / FRT 50<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 41.0 and 12.9 Southward movement must be inspected at mile 41.0 Southward movements not inspected between 31.0 and 21.0 speed limit 15MPH between 21.0 Newmarket Sub. and 25.2 York Sub. |
| #15 Newmarket Sub.<br>Mile 12.9 - 2.4 | Mile 2.5 - 9.5 < PASS 35 / FRT 35<br>Mile 9.5 - 12.9 < PASS 75 / FRT 60 | DANGEROUS COMMODITIES<br>Speed limit 35MPH between 2.5 and 12.9. | Mile 12.9 - 9.5 < PASS 75 / FRT 60<br>Mile 9.5 - 2.5 < PASS 35 / FRT 35 | DANGEROUS COMMODITIES<br>Speed limit 35MPH between 12.9 and 2.5 |

TRAIN SPEEDS AND INSPECTION PROCEDURES

| Corridor # | East or North Movements | | West or South Movements | |
|---|---|---|---|---|
| | Maximum Speeds | Special Instructions | Maximum Speeds | Special Instructions |
| #16 Weston Sub.<br>Mile 0.0 - 17.0 | Mile 17.0 - 9.3 < PASS 80 FRT 60<br>Mile 9.3 - 8.2 < PASS 35 FRT 35<br>Mile 8.2 - 5.3 < PASS 80 FRT 60<br>Mile 5.3 - 2.5 < PASS 55 FRT 35<br>Mile 2.5 - 1.1 < PASS 35 FRT 35 | North TK 14.1 - 12.5 < PASS 30 FRT 30<br>North TK 3.1 - 2.5 < PASS 35 FRT 35<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 17.0 and 1.1<br>Trains must be inspected within 20 miles of previous inspection. | Mile 1.1 - 3.1 < PASS 35 FRT 35<br>Mile 3.1 - 5.3 < PASS 55 FRT 35<br>Mile 5.3 - 8.2 < PASS 80 FRT 60<br>Mile 8.2 - 9.3 < PASS 35 FRT 35<br>Mile 9.3 - 17.0 < PASS 80 FRT 60 | South TK 2.5 - 5.5 < PASS 35 FRT 35<br>North TK 12.5 - 14.1 < PASS 30 FRT 30<br>Strachan Avenue 1.6 < PASS 10 FRT 10<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 1.1 and 17.0<br>Trains must be inspected within 20 Miles of previous inspection. |
| #17 Oakville Sub.<br>Mile 1.1 - 8.4 | Mile 8.4 - 3.1 < PASS 80 FRT 60<br>Mile 3.1 - 1.8 < PASS 70 FRT 60<br>Mile 1.8 - 1.1 < PASS FRT RESTRICTED SPEED | TK Mile 3.1 - 1.8 < PASS 40 FRT 40<br>DANGEROUS COMMODITIES<br>Speed limit 35 MPH between 8.4 and 1.1. All movements must be inspected at Mile 8.0 including CP movements entering at Bathurst St. and Mile 27.7. | Mile 1.1 - 1.8 < PASS FRT RESTRICTED SPEED<br>Mile 1.8 - 3.1 < PASS 70 FRT 60<br>Mile 3.1 - 8.4 < PASS 80 FRT 60 | TK 1.8 - 3.1 < PASS 40 FRT 40<br>TK 3.1 - 6.1 < PASS 40 FRT 40<br>Strachan Ave. 1.6 < PASS 10 FRT 10<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 1.1 and 8.4 |
| #18 Oakville Sub.<br>Mile 8.4 - 27.1 | Mile 27.1 - 8.4 < PASS 80 FRT 60 | TK3 Mile 21.7 - 20.7 < PASS 30 FRT 30<br>TK1 Mile 13.0 - 13.2 < PASS 60 FRT 60<br>TK3 Mile 10.3 - 9.3 < PASS 60 FRT 50<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 27.1 and 8.4. All movements must be inspected at Mile 8.0 including CP movements entering at Bathurst St. and Mile 27.7 CP Movements must be inspected at Hamilton before entering Oakville Sub. Movements from Grimsby Sub. must be inspected at Hamilton Yard. | Mile 8.4 - 27.1 < PASS 80 FRT 60 | TK3 Mile 9.3 - 10.3 < PASS 60 FRT 60<br>TK1 Mile 13.0-13.2 < PASS 60 FRT 60<br>TK3 Mile 20.7-21.7 < PASS 30 FRT 30<br>Strachan Ave. 1.6 < PASS 10 FRT 10<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 8.4 and 27.1<br>CP Rail movements must be inspected at Canpa before entering Oakville Sub. |

APPENDIX TABLE D/1

TRAIN SPEEDS AND INSPECTION PROCEDURES

| Corridor # | East or North Movements | | West or South Movements | |
|---|---|---|---|---|
| | Maximum Speeds | Special Instructions | Maximum Speeds | Special Instructions |
| #19 Belleville Sub.<br><br>Mile 196.0 - 181.48 | Mile 196.0 - 181.48 PASS 65 / FRT 60 | Mile 195.9 PASS 40 / FRT 40<br>DANGEROUS COMMODITIES<br>Speed limit 35 MPH between 196.0 and 181.48 Mile 183.8 pullby or standing inspection point<br><br>Special Instruction AA | Mile 181.48 - 196.0 PASS 65 / FRT 60 | Mile 195.9 PASS 40 / FRT 40<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 181.48 and 196.0. Mile 183.8 pullby or standing inspection point.<br><br>Special Instruction AA |
| #20 Belleville Sub.<br><br>Mile 206.0 - 196.0 | Mile 206.0 - 199.5 PASS 75 / FRT 60<br>Mile 199.5 - 196.0 PASS 65 / FRT 60 | Mile 206.0-196.0 North & South Track PASS 60 / FRT 60<br>DANGEROUS COMMODITIES<br>Speed limit 35 MPH between 206.0 and 196.0 pullby or standing inspection at Toronto Yard<br><br>Special Instruction AA | Mile 196.0 - 199.5 PASS 65 / FRT 60<br>Mile 199.5 - 206.0 PASS 75 / FRT 60 | Mile 196.0-206.0 North & South Track PASS 60 FRT 60<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 196.0 & 206.0 Pullby or standing inspection at Toronto Yard.<br><br>Special Instruction AA |
| #21 Belleville Sub.<br><br>Mile 211.5 - 206.0 | Mile 211.5 - 209.6 PASS 30 / FRT 30<br>Mile 209.6 - 206.0 PASS 50 / FRT 50 | DANGEROUS COMMODITIES<br>Speed limit 30 MPH between 211.5 and 209.6<br>Speed limit 35 MPH between 209.6 and 206.0 | Mile 206.0 - 209.6 PASS 50 / FRT 50<br>Mile 209.6 - 211.5 PASS 30 / FRT 30 | DANGEROUS COMMODITIES<br>Speed limit 35MPH between 206.0 & 209.6<br>Speed limit 30MPH between 209.0 & 211.5 |
| #22 Havelock Sub.<br><br>Mile 179.0 - 161.33 | Mile 179.0 - 161.3 PASS 30 / FRT 30 | DANGEROUS COMMODITIES<br>Speed limit 30 MPH between 179.0 and 161.3 Toronto Yard pullby or standing inspection Point<br><br>Special Instruction AA | Mile 161.3- 179.0 PASS 30 / FRT 30 | DANGEROUS COMMODITIES<br>Speed limit 30MPH between 161.3 & 179.0 Toronto Yard and Mile 158 pullby or standing inspection points.<br><br>Special Instruction AA |
| #23 North Toronto Sub.<br><br>Mile 5.9 - 0.0 | Mile 5.8 - 0.0 All Trains 50 | Mile 5.8 Diamond West Toronto All Trains 20<br>DANGEROUS COMMODITIES<br>Speed limit 20 MPH at 5.8 Diamond West Toronto<br>Speed limit 35 MPH between 5.8 and 0.0 | Mile 0.0-5.8 All Trains 50 | Mile 5.8 Diamond West Toronto All Trains 20 MPH<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 0.0 and 5.8<br>Speed limit 20MPH at 5.8 |

APPENDIX TABLE D/2

TABLE 12/2

TRAIN SPEEDS AND INSPECTION PROCEDURES

| Corridor # | East or North Movements | | West or South Movements | |
|---|---|---|---|---|
| | Maximum Speeds | Special Instructions | Maximum Speeds | Special Instructions |
| #24 Galt Sub.<br>Mile 9.6 - 4.9 | Mile 9.6 - 4.9 PASS 75 / FRT 50 | Mile 9.6 - 8.5 PASS 65 / FRT 60 Mile 8.5 - 4.9 PASS 50 / FRT 50<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 9.6 and 4.9. Mile 64.0 pullby or standing inspection point<br>Special Instruction AA | Mile 4.9 - 9.6 PASS 75 / FRT 50 | Mile 4.9-8.5 PASS 50 / FRT 50 Mile 8.5-9.6 PASS 65 / FRT 50<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 4.9 and 9.6. Mile is 5.8 pullby or standing inspection point.<br>Special Instruction AA |
| #25 Galt Sub.<br>Mile 25.87 - 9.6 | Mile 25.8 - 9.6 PASS 75 / FRT 50 | Mile 14.2 - 12.6 60<br>Mile 12.6 - 9.6 65<br>South TK 22.0 - 18.0 50<br>18.0 - 14.2 60<br>North TK 25.87 - 22.0 70<br>22.0 - 19.0 50<br>19.0 - 14.2 60<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 25.8 and 9.6. | Mile 9.6 - 25.8 PASS 75 / FRT 50 | Mile 9.6-12.6 65<br>Mile 12.6-14.2 60<br>PASS TRAINS ONLY SOUTH TK 14.2-18.0 60<br>18.0-22.0 50<br>NORTH TK 14.2-19.0 60<br>19.0-22.0 50<br>22.0-22.87 70<br>DANGEROUS COMMODITIES<br>Speed limit 35 MPH between 9.6 and 25.8. |
| #26 Galt Sub.<br>Mile 4.9 - 2.3 | Mile 4.9 - 2.3 PASS 75 / FRT 50 | Mile 4.9 - 4.2 All Trains 25<br>Mile 4.2 - 2.3 PASS 50 / FRT 50<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 4.2 and 2.3<br>Speed limit 25MPH between 4.9 and 4.2 | Mile 2.3 - 4.9 PASS 75 / FRT 50 | Mile 4.2 - 2.3 PASS 50 / FRT 50<br>Mile 4.9 - 4.2 All Trains 25<br>DANGEROUS COMMODITIES<br>Speed limit 35 MPH between 2.3 and 4.2<br>Speed limit 25 MPH between 4.2 and 4.9 |
| #27 Mactier Sub.<br>Mile 32.5 - 0.0 | Mile 0.0 - 32.5 All trains 60MPH | Mile 0.7 Diamond West Toronto 20<br>Mile 0.0-4.9 35 Mile 5.0-10.2 45<br>Mile 9.1-9.2 40 Mile 13.0-18.0 50<br>Mile 26.0-32.5 55<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 0.0 and 26.4. Mile 7.8 pullby or standing inspection point.<br>Special Instruction AA | Mile 32.5 - 0.0 All trains 60 MPH | Mile 32.5-26.0 55 Mile 18.0-13.0 50<br>Mile 9.2-9.1 40 Mile 10.2-5.0 45<br>Mile 4.9-0.0 35 Mile 0.7 Diamond West Toronto 20<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 26.4 and 0.0 mile 7.8 pullby or standing inspection point.<br>Special Instruction AA |
| #28 Canpa Sub.<br>Mile 2.6 - 0.0 | Mile 2.6 - 0.0 All trains 25MPH | DANGEROUS COMMODITIES<br>Speed limit 25MPH between 2.6 and 0.0. Speed limit on trains from CN Oakville Sub. is 25MPH between Canpa and Lambton Yard. | Mile 0.0 - 2.6 All trains 25 MPH | DANGEROUS COMMODITIES<br>Speed limit 25MPH between 0.0 and 2.6<br>Speed limit 35MPH between 0.0 Canpa Sub. and 18.0 CN Oakville Sub. |

TABLE 12/3

TRAIN SPEEDS AND INSPECTION PROCEDURES



| Corridor # | East or North Movements | | West or South Movements | |
|---|---|---|---|---|
| | Maximum Speeds | Special Instructions | Maximum Speeds | Special Instructions |
| #29 Orangeville Sub.<br>Mile 34.6 - 0.0 | Mile 0.0 - 34.6 All trains 35MPH | Mile 0.0-0.5 30MPH Mile 22.8-23.7 10MPH<br>Mile 25.9 25MPH<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 0.0 and 34.6<br>EXCEPT<br>Mile 0.0 - 0.5 30MPH Mile 22.8-23.7 10MPH<br>Mile 25.9 25MPH | Mile 34.6-0.0 All Trains 35MPH | Mile 25.9 25MPH Mile 23.7-22.8 10MPH<br>Mile 0.5-0.0 30 MPH<br>DANGEROUS COMMODITIES<br>Speed limit 35MPH between 34.6 and 0.0<br>EXCEPT<br>Mile 25.9 25MPH Mile 23.7-22.8 10MPH<br>Mile 0.5 - 0.0 30MPH |
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